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ABSTRACT

This document is a "methodological annex" to volume I of the Women in Science and Technology in Australia (WISTA) final research report. The 10 discussion papers that make up this document deal with the 10 core factors of influence that formed one main axis of the study's theoretical framework for inquiry. A diagram illustrates this framework. The discussion papers were used to focus and encourage feedback from academic staff in the leadership of the scientific and technological disciplines surveyed in the WISTA project. The project tested knowledge and attitudes and sought informed opinions on needs and priorities by circulating a discussion paper for each of the 10 factors. The 10 core factors were then related to four concepts: (1) institutional ecology; (2) critical mass; (3) the perceived masculinity or femininity of disciplines; and (4) the constructed style and content of scientific and technological disciplines. The 10 factors and papers concern: (1) same sex role models as a positive factor of influence for women; (2) the mentor process, potentially negative or positive; (3) the image of different branches of science and technology (male, female, or sex neutral; socially responsible or systems and machine oriented); (4) male attitudes to females in nontraditional disciplines; female attitudes (self-esteem, or towards peers); (5) single-sex versus coeducation as positive or negative influences; (6) prerequisites and school patterns of curricular choices as critical filters; (7) mathematics as a negative critical filter; (8) careers education and vocational counseling as positive or negative influences; (9) women's support networks as positive influences; and (10) affirmative action projects in science and technology as positive influences. (DK)

PREFACE

This volume should be used in conjunction with Volume I (Final Research Report) of the UQ WISTA Research Project, entitled Women in Science & Technology: the Institutional Ecology Approach. It contains the original ten Discussion Papers written in 1985 and 1986, produced for use in the group interviews and in consultation with the Deans, Professors and Heads of Schools and other academic staff consulted in the UQ WISTA survey of five Universities and five Institutes of Technology. ***The papers do not represent a complete state-of-the-art summary, even as at 1985 and 1986.***

They represent:

(a) the main research findings seen as sound and relevant to the questions and hypotheses raised by the UQ WISTA research;

(b) a starting point to inform scientific and technological staff of factors of influence which were not necessarily rooted in the discipline itself; and

(c) the definition of focussed questions as a result to which we invited informed answers and feedback.

This volume should be read, therefore in this strictly methodological context.

I Introduction

1.1 The ten Discussion Papers which comprise this methodological Annex to Volume I of the UQ WISTA Final Research Report (Women in Science & Technology: the Institutional Ecology Approach), deal with the ten core factors of influence which formed one main axis of our theoretical framework for enquiry. (Diagram A on the following page illustrates this.) The Discussion Papers were used to focus and encourage feedback from academic staff in the leadership of the scientific and technological disciplines surveyed in the UQ WISTA project.

Ten Core Factors: A Central Framework

1.2 Very early in our literature review and search, and after preliminary analyses of what limited statistical data were available for Australia, two things became evident. Firstly, there was a core of factors (not of equal importance) which were cited by almost all overseas countries which had mounted relevant research. Reports from the major international organisations endorsed most of these as widely relevant. Whatever the ultimate relevance or influence of these might prove to be in our Australian study, clearly they could not be ignored and should form the basis of one central set of issues to be investigated. They can be summarised as:

* same-sex ***role models*** as a positive factor of influence for women

* the ***mentor*** process, potentially negative or positive

* the ***image*** of different branches of science and technology (male, female or sexneutral; socially responsible or systems and machine-oriented)

* ***male attitudes*** to females in "nontraditional" disciplines; ***female attitudes*** (self-esteem, or towards peers)

* ***single-sex*** versus ***coeducation*** as positive or negative influences

* ***prerequisites*** and school patterns of curricular choices as critical filters

* ***mathematics*** as a negative critical filter

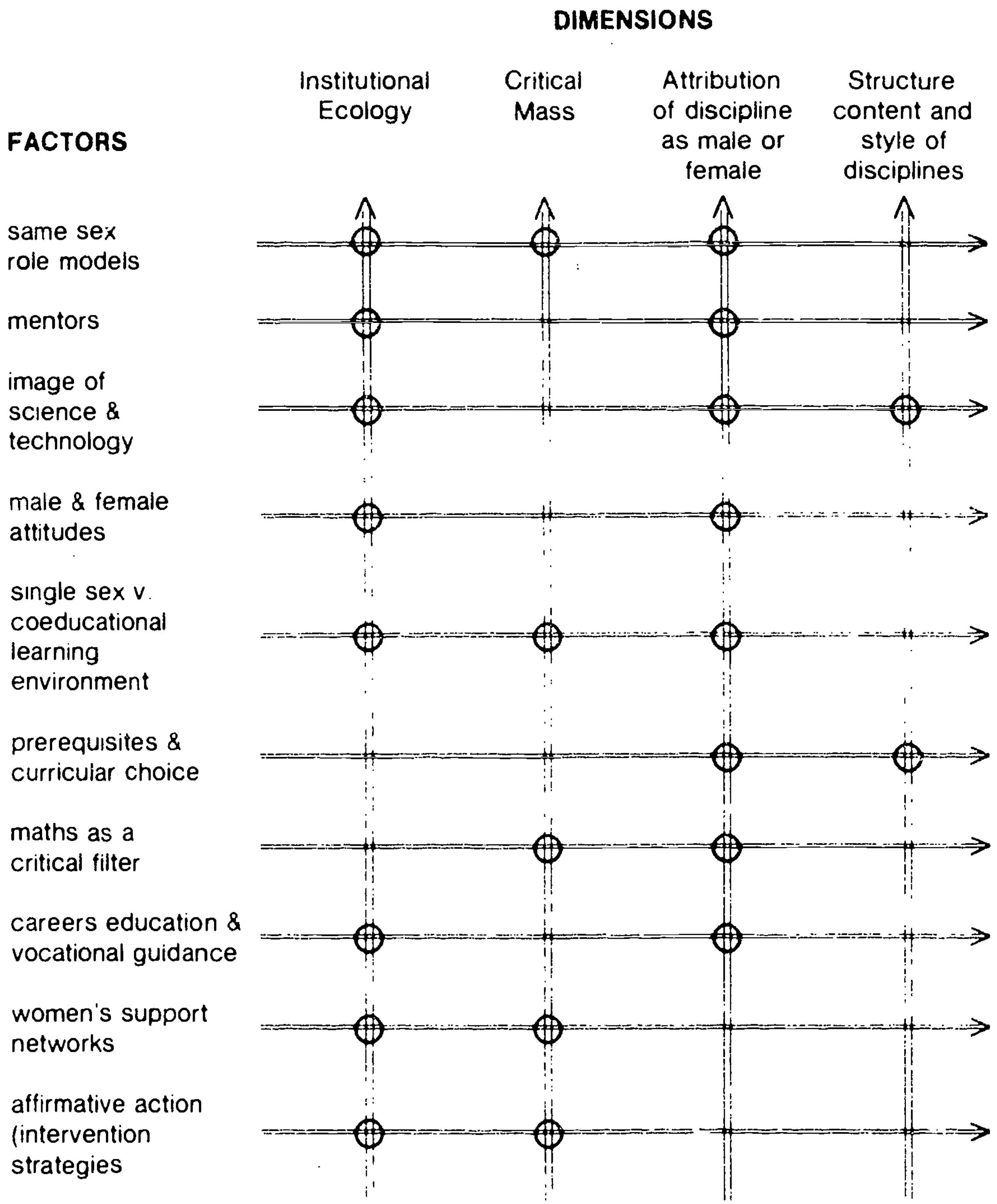
* ***careers education*** and vocational counselling as positive or negative influences

* ***women's support networks*** as positive influences

* ***affirmative action*** projects in science and technology as positive influences.

DIAGRAM A

WISTA - THEORETICAL FRAMEWORK



Note: The study investigates only the intersection of the factors and dimensions, as marked ○. For example, image is seen as related to ecology, attribution, and structure and content, but not to critical mass. The single sex factor is related to ecology and critical mass but not attribution nor structure, and so on.

1.3 These, referred to hereafter as **<u>the ten factors</u>**, formed a major part of our theoretical framework. Diagram A illustrates how we related these to four concepts or dimensions of wider significance, that is

* institutional ecology
* critical mass
* the perceived "masculinity" or "femininity" of disciplines
* the constructed style and content of scientific and technological disciplines.

It will be seen from Diagram A that an intersection point (of hypothesised interrelationship) is shown only between some factors or concepts. Thus, for example, image is seen as related to institutional ecology, male or female attribution and the construction of disciplines but <u>not</u> to critical mass; and so on.

DIALOGUE ON RESEARCH AND THEORY: A CATCHMENT AREA OF ATTITUDES AND ISSUES

2.1 It has been a matter of some interest that social science research, even when highly qualitative in nature, has tended to see a need to authenticate its approval by locating its analyses of earlier theory wherever possible in standardised, quantitative, statistically controlled surveys. Where the required answers can be properly supplied by standardised computerised data ranked on a several point scale, this is, of course, sound enough. It does not, however, serve the purpose of all qualitative objectives. We therefore used two methods to replace questionnaire techniques: (a) group interviews and (b) the circulation of Discussion Papers to which academic and professional staff in the survey institutions were asked to respond.

2.2 That is, we have sought to build in a dialogue between two levels of thought which are perhaps a little less polarised than Medawar's (1972) perceived distinction between the imaginative and the critical. In other words, we wished to set up a dialogue between the independent researchers creating theory in the area of women's educational underachievement or stereotypic channelling in science and technology, and the academic staff who actually play a role in constructing the discipline in higher education institutions.

Group Interviews

2.3 Accordingly, we asked the survey institutions to cooperate firstly in setting up a series of ***group interviews*** in each institution in 1985 and 1986 with senior academic and professional staffs. The groups were to be not fewer than about eight and not more than about fifteen in number, and should include:

* as many as possible of the key policymakers from the Faculties or Departments in which our survey disciplines were located, viz Pro Vice Chancellors, Deans, Professors and Heads of Schools or Departments;

* other academic staff from the survey disciplines interested to come;

* professional staff in the areas of careers advice, counselling and student services and (where appropriate) Equal Opportunity staff.

2.4 The 1985 and 1986 meetings arranged with senior academic staff were not only set up in order to explain the complexity of the project and to negotiate agreements on the supply and verification of data. Also built in to this group interview process and into our written continuing dialogue with the ten institutions, was a "sieving" process using experienced academics as a form of field monitoring of previous research and of the reality of some of the more relevant research findings, in the normal higher education process. That is, we were applying Cohen and Manion's (1986) principle cited earlier that interpretive theory *"must make sense for those to whom it applies"*, and the pursuit of multiple hypotheses which Glaser and Strauss (1972) regard as central to field work which aims to lead to grounded theory.

2.5 Between nine and twelve meetings took place at each institution in both 1985 and 1986, except for the University of Western Australia and Western Australian Institute of Technology which were added to the survey in 1986 and therefore took part only in 1986 interviews. The one and a half hour meetings were all tape recorded, and an analysis completed of (a) the issues raised by academic staff in response to our agenda, (b) the comments, reactions, evidence and experience or judgements of academic staff on the ten factors which we raised in each meeting as potential influences, and (c) any new factors or issues raised by staff, not already covered by our work. Further methodological commentary on the group interviews is included in Volume I.

The Ten Factors: Ten Discussion Papers

2.6 Our main strategy for testing knowledge and attitudes and for seeking informed opinion on needs and priorities, was to circulate a series of ten brief Discussion Papers (one on each of the ten factors) over a period from June 1985 to November 1987, to which academic staff were asked to respond in writing. The papers set out firstly to identify briefly the problem or issue (What is role-modelling and why is it important? Why is single-sex education or coeducation an issue in female achievement? What is the main problem about girls' achievement in mathematics?). We sought secondly, to report on relevant research in the area which was related both to female involvement in science and technology and to higher education; and thirdly, to pose questions which would as a result need to be addressed by higher education institutions. The papers were consciously limited in length to from four to seven pages to encourage academic staff actually to read them. The early papers were circulated before the interviews; most papers were circulated afterwards, and staff were encouraged to write in with comments, reactions and insights. The papers were sent principally to Deans and Professors, with requests that they be made available to staff in the disciplines concerned; and to other key personnel (Pro Vice Chancellors with responsibility for the survey disciplines; Deputy Vice-Chancellors).

2.7 As a result of many enquiries from both researchers and personnel with responsibility for inservice education and training, the ten papers are reproduced in their original form in this volume. ***It should be noted that our view of each of the factors has been considerably updated as a result of the UQ WISTA Research, and that these do not represent necessarily, our 1992 position.***

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EMB/3/86

WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 1

ROLE MODELS

as a potential factor of influence in attracting women to science and technology

Discussion Paper 1 by Eileen Byrne and Elizabeth Hazel in the WISTA survey of ten Australian higher education institutions, 1986

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

As part of the policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

ROLE MODELS

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it in three ways:-

(a) discuss the specific questions set out at the end of the paper at the meeting to be arranged at your University/Institute for this purpose both in relation to your own discipline and your institution as such, and in the light of the research summary;

(b) raise any other aspects seen by you as directly relevant to the issues raised in this paper but not covered by the summary; and

(c) send Professor Byrne at the University of Queensland, a considered written response if you wish, either individually or as groups, not later than 15 June. In particular, written recommendations for possible action by higher education institutions or by Federal or State education authorities, will be welcome.

What is role-modelling?

The original concept of role-modelling derives from research drawing on educational psychology. Kagan (1964), for example, identifies a sexrole standard and a sexrole identity. The former is a "learned association between selected attributes, behaviours and attitudes, on the one hand, and the concepts of male and female on the other", and works partly through identification with role models in the adult:child interaction process (parent and teacher). He identifies sexrole identity as rather "the degree to which an individual regards himself or herself as masculine or feminine", and in acquiring this sexrole identity, the role model needs in Kagan's view to be a caring one, to be seen to have the control of goals and skills the child wishes to acquire, and the child needs to be able to see a realistic similarity between himself or herself and the adult. Kagan is inconclusive on whether the strength of the sextyping of the role model does or does not affect the child's security of sex identity. The role-model angle of role identity has been debated further since - Mischel (1966 and 1970) for example argues that more of our identity comes from the social learning of behaviour reinforcement or negative influence, while Gelb (1973) sees sex identity as having been in fact distorted by "coercive institutionalisation of sex roles".

Overall there would be more agreement with the view that when children move from undifferentiated sex roles (stage I) to polarised sex roles (stage II) in which societal values and pressures produce a perceivedly "normal" set of behaviour patterns for each sex, (Robinson & Green, 1970), the role-modelling process as described by Kagan still plays an important part.

The role-modelling concept has now been extended to a belief that in the process of shaping "normal" or "deviant" vocational aspirations in adolescence or adult life, or of forming occupational goals, each sex is reinforced more securely in decision making by seeing same-sex role models ahead of them in the power structure (leadership), in the relevant occupational area (science, technical work), or in the sphere of influence they aspire to (politics). In this, relevant theoretical and empirical research tends to support Kagan's perception that the person being influenced by the role model needs to be able to see a "realistic similarity" between herself or himself and the role model; the "rubric of exceptions" should not operate. There is a need also to separate

(a) the personal role modelling process in which adolescents or young adults use the same-sex identification to strengthen personal decisions to make a vocational or subject choice nontraditional for their sex, from

(b) the use of role modelling as a strategy to break the stereotype of the exclusive masculinity of the image of maths, science or technology, from

(c) the contribution of role modelling to "normalising" an area as either sexneutral, or acceptable or suitable for the sex now in the minority - in this instance generalising a feeling of female normality.

(Role modelling can also of course work as a negative process.)

What does relevant recent research tell us?

There are two main research sources - the first refers to the nature and possible influence of role modelling and the second reports special projects to open up nontraditional education, training and employment to women which include the conscious use of female role models in science and technology. The role of a crucial older woman is prominent in the biographies of many successful professional women, from Margaret Mead to

Helen Deutsch (Douvan, 1976). In the specific case of science, a recent historical scholarly study of American women scientists has documented the importance of both role models and mentors (Rossiter, 1984). The evidence on actual measured effect, as distinct from belief in the role modelling theory, is however not entirely decisive either way. Some writers and researchers are prepared to assert that lack of female role models in science has been seen to discourage enrolment by girls (Graham, 1970; Hardin and Dede, 1973). Vockell and Lobonc (1981), on the other hand, looked at girls' school science classes in mixed and single sex schools and were unable to identify clearly, a positive relationship between presence of female science teachers and the girls' perception of physical science as "masculine" or "feminine". Yet Entwhistle and Duckworth (1977) looked further at choices of science courses in secondary schools and concluded that teachers do in fact serve as st ong role models for many school students.

Harding (1983) suggests that it may in fact be partly that "teaching style and individual behaviour may be more influential than the sex of the teacher". And when Welch and Lawrenz (1982) looked at the characteristics of male and female science teachers in a fourteen state region of USA, they did identify several significant differences between the two groups (for example, female teachers rated higher on measures on interests in science and receptivity to change, male teachers higher on science knowledge). And Eggleston et al (1976) suggested that teaching style was highly correlated with sex, more women science teachers tending to use <u>pupil-centred</u> enquiry methods and more men using problem solving <u>teacher-centred</u>, teacher-initiated styles. The former style used by more women teachers, was seen to be more effective in retaining girls in physics and chemistry, in the British schools surveyed.

At the University level, Goldstein (1979) looked at the effect of same-sex and cross-sex role models on the subsequent academic productivity of scholars. She claimed that scholars in the two <u>same sex</u> conditions (female PhD's with female supervisor, male PhD's with male supervisor) published significantly more research than did scholars in the two cross-sex conditions. The results need to be interpreted cautiously - a <u>causal</u> relationship between supervisor/student, sex and productivity cannot be proven. Nor can we <u>know</u> whether and how a role modelling process takes place without study of individual cases. Nevertheless, the data raise interesting questions.

Strauss identifies societal attitudes or "sexrole ideology" which lead to sexdifferentiated teaching, as a major barrier in American education, and sees one strategy as the <u>importation</u> in the careers programmes of Schools and Colleges of "a women scientist or engineer from the community who is happy, successful and whose work may be perceived as important enough to be an alternative to traditional female careers".

Strauss asserts a preference within the female role model range: "The ideal role model for any girl is a career oriented mother who is happy and successful in both employment and family endeavours" (Strauss, 1978).

At the other end of the literature, a number of studies report on intervention strategies using female role models. Purdue University has increased its female recruitment into engineering over ten years from 47 in 1967, to 817 women in 1976, to over 1000 women engineering under-graduates in 1979. While the Purdue Model Program for Women entering Engineering (funded partly under the Women's Educational Equity Act) needs to be seen as a whole, one of the core elements is the use of lecture discussions of career engineering and contemporary problems by women lecturers explicitly chosen as role models (happy, married, successful etc...) (Daniels and Lebold [1982]; Byrne, [1986]). The American National Science Foundation has sponsored and funded a project specifically aimed at providing more women role models in science, by a programme in which groups of women scientists and technologists visit schools to talk about their work and their lives (Weiss et al, 1978).

The British Girls into Science and Technology (GIST) project, working with junior secondary children in a range of schools, introduced a particular intervention strategy on role-modelling in the first year - the VISTA programme (visiting scientists and technologists). The aim was to provide the children with role models of women working in "masculine" occupations who enjoyed their work and were successful at it. The preparatory training which fifty women undertook, included briefing sessions, discussion of 11 year old essays about a proposed interview with a woman scientist, and a pilot run before a television camera which was then discussed by the briefing group to improve the women scientists' interaction with school children. The women have been coached in strategies to ensure that girls participate and do not let boys dominate the questioning (Smail, Whyte and Kelly, 1982).

QUESTIONS

We still do not know enough about whether, or how, same-sex role modelling in adolescence and adulthood is effective. This summary is only a very brief selection of a wider literature.

In the context of the WISTA project, we are now asking:-

(a) Can you see a fulltime or parttime woman in your discipline who you think is performing one or more of the positive functions of a role model? What is her level or grade? Can you assess her likely influence on women students?

(b) Can you suggest ways, in your discipline or area, in which you could (or do?) create same-sex role modelling as a process of "normalising" the disciplines for women, by bringing in external women?

(c) Given the agreed principle that only <u>equally qualified</u> women be appointed or used, what part could you see the issue of positive role modelling playing in the future policy of this University or Institute? What kinds of options do you think are both feasible and professionally acceptable?

(d) How influential do <u>you</u> think this factor is?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 2

MENTORS

as a potential factor in helping the progression of women in higher education in science and technology

Discussion Paper 2 by Eileen Byrne and Elizabeth Hazel in the WISTA survey of ten Australian higher education institutions, 1986

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

As part of the policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

MENTORS

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Colleagues are invited to read this paper and to respond to it in three ways:-

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(b) raise any other aspects seen by you as directly relevant to the issues raised in this paper but not covered by the summary; and

(c) send Professor Byrne at the University of Queensland, a considered written response if you wish, either individually or as groups, not later than 15 June. In particular, written recommendations for possible action by higher education institutions or by Federal or State education authorities, will be welcome.

What do we mean by Mentors?

What is the Mentor factor?

In looking at the profiles of women seen as successful in breaking in to "nontraditional" areas, a common theme has emerged of the presence of a "mentor", a sponsor, an enabler, a senior or leadership figure who has been more than a role model - rather an opener of doors, a sponsor to financial scholarships or awards, a colleague who has created an "arena" for the protegé to show her gifts. Undoubtedly, a mentor who is also female and a role model will be doubly influential. But sponsorship, grants, the award of jobs, are reflections of the power structure. In science and technology, women are fewer than 2% of the top leadership. Mentors will, therefore, more often still be male. The role of mentors and sponsors is in fact well documented historically in the biographies of male and female scientists alike. T.H. Huxley, in addition to his other roles, was a key figure in opening up science education to women in Victorian England. In Rossiter's (1982) account of women scientists in America from the early 19th century to the 1940s, the key factor in the accessing of science education for early pioneers was the specific sponsorship of sympathetic male scientists. Amos Eaton in particular not only helped early women scientists such as Emma Hart Willard and Mary Lyon, but trained them to train other women. Maria Mitchell, the astronomer and the first woman member of the American Academy of Arts and Sciences, owed her professorship at Vassar College to the specific keenness of Matthew Vassar to have a prominent woman scientist on his staff. (She also became a key role model and promoter of science education for women.)

Today, a number of different ways in which the mentor/sponsor role works, have been documented. At pre-university stage, science teachers in schools may take particular trouble to seek out access to scholarships for their gifted girls. In higher education it is, however, not only more complex but also more hidden, implicit, undefined. The system works in relation to such aspects as:-

* recommendation for awards
* recommendation for postgraduate scholarships
* recommendation and appointment to parttime tutorships to enable concurrent postgraduate research
* advice and encouragement to progress over barriers
* giving students more practical experiences in laboratory experiments etc with lecturers
* enhancing a student's "visibility" (seminars, joint papers, conference attendance)
* discussing the latest scientific or technological work with students: brainstorming.

<u>What does the research tell us?</u>

While there is little research literature specifically on the mentor factor as such, the issue is raised by many writers as one of a number of influences needing further examination. Shapley (1975) writes that every college student in science needs "an interested professor (usually male)" to gain entrance to a graduate department, or to the kind of experience which would lead to publication in a recognised journal. Strauss (1978) suggests that "a sponsor's perception of a female student's <u>commitment</u> to a career rather than to motherhood, may determine his or her interest in the student's career plans". Goldstein (1979) quotes a range of earlier research in which writers suggest several reasons why a potential male sponsor may be reluctant to sponsor a woman professionally. One theory is that he does not see her as someone who will carry on his ideas and values (see the Image of Science paper in this series for differential male and female attitudes to science). Others postulate that male scientists are likely to believe that women's family commitments will interfere with professional ones (ie that mothering, but not fathering, is exclusive). Others see male sponsors as doubting that women need jobs, grants, research posts as much as men because they will not need economic independence (Epstein, 1970; Lewin and Duchan, 1971; White, 1970). Goldstein's own (American) research investigated subsequent academic productivity of students working with same-sex and cross-sex supervisors, and concluded both sexes published more with same-sex than with cross-sex supervisors. The data must be regarded with some caution, since a causal relationship between scholar/adviser, sex and productivity could not be proven, but it raises questions about, for example, whether either sex (possibly unconsciously) is more prone to encourage more overtly, their own sex; or whether the role modelling process is at work; or both. (And how is supervision allocated? How much by choice of student, how much by assignment by Head of Department?)

Martha White (1970) discusses in some detail, the informal professional training processes which operated at the Radcliffe Institute whose women scholars she interviewed. White recognises that many professions and occupations have periods analogous to that of the medical internship or residency during which the individual learns to behave in ways other people in the field regard as "professional". Such socialization consists of learning the roles, the informal valued and attributed, and the expectations which are an important part of real professional life and result in the gaining of a firmer image of self as a competent and adequate professional. This kind of learning is "caught" not "taught" and is a valued by-product of acceptance and challenging association with other professionals. In science in particular the exclusion from informal channels of communication is important since knowledge is growing so rapidly. At any time only part of it is in the literature yet women may have more limited access to the brains of fellow scientists than men. When women are hesitant to put themselves forward or to protest their exclusion, the pattern of exclusion is confirmed. White's analysis stresses what Egerton described as "biological storage" rather than mechanical or library storage; access to the knowledge in the brains of scientists and technologists which, it is held by both White and Bernard (1964), is more often shared in brainstorming discussions, informal interaction, between male lecturers and male students or male researchers, than male scientists and female students or researchers.

QUESTIONS

For fairly obvious reasons, we do not yet know enough about the overt and assumed patterns of mentorship which operate in higher education institutions today. A much wider research literature than that cited here, records a prevailing belief that the mentor system advantages males more than females. In the context of the WISTA project, we are now asking:-

(a) Which of the mentor roles listed above do you see as more important or more influential in your discipline?

(b) Do you consider that the ways in which sponsorship or mentoring work in your institution either do, or may, disadvantage women students?

(c) Are you able to identify any observed differences in the way in which these operate for male and female students respectively in helping access to postgraduate work?

(d) Is there any way of moving from the current idiosyncratic approach to a more clearly criterion based model? Is this desirable, or not?

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EMB/3/86

WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 3

AFFIRMATIVE ACTION

Discussion Paper 3 by Eileen Byrne and Elizabeth Hazel in the WISTA survey of ten Australian higher education institutions, 1986

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

As part of the policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

AFFIRMATIVE ACTION

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it in three ways:-

(a) discuss the specific questions set out at the end of the paper at the meeting to be arranged at your University/Institute for this purpose both in relation to your <u>own discipline</u> and your <u>institution</u> as such, and in the light of the research summary;

(b) raise any <u>other</u> aspects seen by you as directly relevant to the issues raised in this paper but not covered by the summary; and

(c) send Professor Byrne at the University of Queensland, a considered written response if you wish, either individually or as groups. In particular, written recommendations for possible action by higher education institutions or by Federal or State education authorities, will be welcome.

<u>What is affirmative action</u>?

Affirmative action is <u>not</u> the same as "positive discrimination" and should be clearly distinguished from it. It is based on inclusion of a disadvantaged group in a special programme and <u>not</u> on exclusion of others by any form of quota. Whereas positive or reverse discrimination is based on opening up new opportunity (eg to blacks or migrants in USA) by a quota system where resources (eg places) are rationed, affirmative action for women does not deny any right to males. It provides or "tops up" educational or training skills which have been hitherto denied to females either explicitly, or indirectly through a sexstereotyped education and social conditioning.

Let us take the example of remedial education in language. Research in the early years of this century showed that whole groups of children - those of the "labouring classes", <u>and more boys than girls</u>, had difficulty in learning to read or to use language discursively. We have therefore naturally provided special programmes, extra resources and differentiated treatment for remedial language in the primary years. This has been variously described as progressive education policy, as developmental work, as diagnostic treatment and as essential educational practice. At no stage has it been conceived as "affirmative action" for the boys who constitute two-thirds of remedial readers in most countries, or "positive discrimination" in educational resource-allocation. It is seen as mainstream normal provision. Proposals, however, to provide remedial, bridging, "topping-up" courses to improve the mathematical and scientific skills of female school and college students or of unemployed young women who have a parallel acquired deficiency and who need special programmes, have been located conceptually in the positive discrimination/affirmative action strand of (peripheral) education policy. It is important to ask why. There is not discriminatory differentiation in such a programme where it is based on diagnosing actual girls and women who need remedial, or additional, or "bridging" mathematical and scientific courses, and not based on normative assumptions that all women are spatially disadvantaged and need special programmes.

Moreover, the causes of (mainly male) language deficiency have been usually targeted as either inadequate early teaching or social class deprivation, both of which are seen as alterable. Spatial or mathematical deficiency in female achievement has, by contrast, tended to be (wrongly) attributed to unproven genetic deficiency of a universal nature by stereotypic assumption; and therefore has been seen as not so susceptible to systemic programmed remedy. Research over the last fifteen years has increasingly placed this theory of biological determinism into question. Affirmative action programmes have shown women's underachievement to be clearly remediable.

Affirmative action in higher education has been widely discussed and researched in the last decade, in this country and overseas. It is differently perceived as an employment issue (for women, blacks or migrants) in relation to the staffing of higher education institutions, or as an educational issue in relation to measures to improve the admission or enrolment rates of women (blacks, migrants).

Affirmative action in staffing

The Australian position is well defined in a Federal Government discussion paper issued in 1984 (Ryan and Evans, 1984), and further contextualised in guidelines related to higher education (Office of Status of Women, 1985). Australian governmental policy does not propose or advocate the use of quotas, and reasserts the principle that progress and increased efficiency will only occur "if jobs are awarded on merit" (Ryan and Evans, 1984). But the concept of what constitutes merit is seen by some to be value-loaded and set in the "normal" profile of a male career (unbroken, workoriented to the detriment of family, and mobile). Abramson illustrated in 1975 that in USA, while none of the affirmative action programmes replaced, or sought to replace, the merit criterion for selection and promotion, many male academics perceived the newly appointed, but equally qualified, women as inferior or having achieved posts by special pleading. Males objected to the principle of preference for a woman if candidates were equally qualified.

The concept of adequate qualifications in terms of the demands of a given job, but not necessarily the best qualified, is now being seriously discussed. It has been publicly supported in Australia by Peter Wilenski. In Denmark, the Danish Committee on Sex Roles and Education has formally recommended that the person with sufficient professional qualifications should be accepted (not necessarily the best if this is in effect overqualification for the level concerned). Once sufficient qualifications and experience are achieved, preference for a woman would not invalidate, in that Committee's view, the merit principle (Committee on Sex Roles, 1984).

In academic work, adherence to the best, as distinct from the sufficiently qualified, candidate will usually, although by no means always, result in a male appointment. This is because the assumption of fulltime parenting or domestic infrastructure by women in early marriage, or of the dual role and its double career/family responsibility, helps men to achieve doctoral qualifications and to publish, but hinders the women. Similarly, wives will characteristically move to further their husband's promotion; less frequently the reverse. Male students who marry during their degree work acquire domestic infrastructure; females, domestic responsibility.

Affirmative action for students

Other papers in this series have referred to initiatives for giving special help in science, maths or technical skills. Special bridging programmes to make up subjects denied by sexstereotypic curricular choices in the secondary school, are one form of affirmative action. Special Summer Schools for female high school students to familiarise them with practical work in scientific and technological disciplines, on the lines of the American and the British Insight models, are another (Byrne, Women & Engineering, op.cit.) For tutors and supervisors actively to encourage women students to consider postgraduate and longterm careers, is a third. Affirmative action is accepting responsibility for remedying a problem we did personally not create: one from the past, from an earlier sector.

Questions which arise in the context of the WISTA study, include

(1) **How do you see the role of Affirmative Action in your Institution as a whole?**

(2) What kinds of problems relating to your specific discipline, create a need for some form of affirmative action? (the maths critical filter? the image problem? the lack of women staff as role models?)

(3) How can/should this be resourced - realistically?

(4) Where would you wish to see priority within your Institution if only some issues can be tackled by affirmative action?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 4

PREREQUISITES AND SCHOOL CURRICULAR CHOICES

Discussion Paper 4 by Eileen Byrne and Elizabeth Hazel in the WISTA survey of ten Australian higher education institutions, 1986

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EMB/3/86

WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

As part of the policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

PREREQUISITES AND SCHOOL CURRICULAR CHOICES

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it in three ways:-

(a) discuss the specific questions set out at the end of the paper at the meeting to be arranged at your University/Institute for this purpose both in relation to your own discipline and your institution as such, and in the light of the research summary;

(b) raise any other aspects seen by you as directly relevant to the issues raised in this paper but not covered by the summary; and

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Sex differentiated subject choices

In Australia, a characteristic pattern of curricular options in upper secondary education is for physics enrolments to be predominantly male, chemistry male dominated but with slightly higher female enrolments, and for biology to be either female-dominated or relatively sex neutral. While maths enrolments may be relatively even up to Grade 10, far more boys than girls study either the most advanced maths, or the highest number of units in maths, and more girls take Social Maths or Maths in Society options. The figures vary in detail between states but the general trends are common. Even more marked is the sex polarity in technical crafts (male) and home craft or design subjects (female) in upper secondary grades (Brown & Fitzpatrick, 1981; Women's Advisers, 1980; Victorian Committee on Equal Opportunity, 1977, et al). Figures for more recent years do not show any consistent change in the female underrecruitment in advanced maths, physics, chemistry and technical subjects at Grade 12. (1985-1987 figures are being obtained from the relevant State bodies.)

This sex-segregation of curricular options is, moreover, common across overseas countries and across cultures. A study of nine EEC countries showed also that the sex polarity becomes relatively more marked in direct relation to the degree to which subjects are seen as prevocational or important for later work-oriented study, or as to be studied in their own right. Consistently, more males pursue subjects seen as vocationally useful and more females choose subjects because of interest, liking or perceived intrinsic value (Byrne, 1979; Danish Ministry of Education; Hannan, Breen et al, 1983). This is particularly so of mathematics, which more boys see as essential for future work and more girls study, when they do so, out of intrinsic interest (Hannan et al, 1983; see also the Mathematics Paper 7 in this series.)

The issue is of importance to tertiary institutions because the lack of the right prerequisites is seen as one important critical filter preventing girls' access to some branches of science and technology at tertiary level.

Formal and Non Formal Prerequisites

A distinction should be drawn between formal and nonformal prerequisites. Formal prerequisites are those identified in university, college of TAFE selection procedures (at an examinable level) as essential before entry to a course, subject or discipline can or will be approved. Non formal prerequisites are those which are presupposed in practice but which are not clearly or prescriptively defined. That is, the selectors and/or those designing tertiary courses assume either

(i) foreknowledge of specific blocks of learning and knowledge; and/or

(ii) prior acquisition of specific skills; and/or

(iii) significant practical "hands-on" experience in a particular area.

For example, it may be assumed in the design of first year courses that incoming students will have had considerable practice in calculus operations, or to have had experience in technical and geometric drawing, or to have had substantial hands-on experience of computing and a knowledge of computer language. It becomes, in practice, essential to have the nonformal prerequisite because either

(a) all things being equal, candidates with the additional skills or knowledge will be preferred as providing a better predictor of success, or

(b) because students will not in fact understand or be able successfully to complete first year work without the assumed prerequisite knowledge or skills, and hence will tend to drop out or fail.

Prerequisites or Requisites?

Affirmative action projects in America, Britain and Sweden aimed at recruiting "mature" women to science and technology (ie older than school leaver direct entrants) have, however, recognised that women's previous sex-differentiated secondary education has frequently prevented them from acquiring necessary prerequisites such as physics, chemistry, advanced maths and technical subjects.

Programmes have therefore attempted to distinguish between prerequisites (ie knowledge or skills essential to have been acquired before entry), and requisite knowledge or skills which are necessary before final completion of the full course (or first year), but which can be acquired additionally after entry to tertiary study.

In the first case, as with advanced maths including calculus or physics, remedies have been seen as either bridging or topping up courses in either the school or technical college system and a delayed entry to the Institution while the "topping up" takes place; or bridging courses provided by the Institute or University and a provisional entry approved to the course a year later provided the candidate completes the named prerequisite subjects first.

In the second case of a concurrent requisite, institutions have tended either to provide special help in the first year or to require that candidates take extra subjects concurrently. Purdue University, Indiana, has built into its first, freshman (sic) year in engineering, specific extra hands-on experience for students (mainly women) who have lacked prior practical experience of tools, machinery and design work. The female students catch up with their peers in performance by the end of the first year. In the UK, candidates for medical schools who lack Human Biology at Advanced Level of the General Certificate of Education before entry, are accepted in some UK universities, provided they make up the necessary study concurrently in the first and second years. Thus, these two examples are requisites, but not prerequisites.

Policy options for change

It may be argued that this is a problem for the secondary school authorities, and in the long term, this is so. The higher education sector has, however, two possible roles to play, to clarify the extent to which lack of certain prerequisites does act as a critical filter and in which cases, and to provide some form of second-chance education for entrants to top up missing knowledge.

In the short term, a useful step may be to reexamine the prerequisite/requisite issue and look at remediation in three possible ways.

(a) Clarifying what areas of knowledge and skills remain a prerequisite for success in each survey discipline and publicising this to schools more effectively, both as subjects per se and within subjects. (See also the Maths paper in this series.)

(b) Defining those subjects or areas of knowledge which are requisite but which can be acquired after tertiary entrance as concurrent courses.

(c) Developing improved statewide programmes of bridging or topping up courses either in the TAFE or High School systems or in higher education institutions (or both) to enable students to make up missing prerequisites.

All three presuppose improved methods of informing school teachers, and notably careers teachers, of the difference between (a) and (b) in each discipline or degree course so that students do not make choices which so limit their tertiary options. In the case of (c), greater collaboration between the school, TAFE and higher education sectors is needed to ensure that each district or subregion has an appropriate range of topping up courses and that students and parents know of these.

In the context of the WISTA survey, colleagues are invited to address the following questions.

(1) What are the established formal and non-formal prerequisites for your discipline?

(2) Are all of these prerequisites, or is it possible for students to make up the missing knowledge concurrently after entry? Which subjects/elements are prerequisites and which requisites?

(3) How can we improve the knowledge of school teachers and careers teachers about the critical filter effect of prerequisites? How can we ensure they know the real prerequisites for different disciplines or branches?

(4) What is the role of a University or Institute in providing bridging or topping up courses? What are the resource implications of this?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 5

MALE AND FEMALE ATTITUDES AS A BARRIER

Discussion Paper 5 by Eileen Byrne and Elizabeth Hazel in the WISTA survey of ten Australian higher education institutions, 1986

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MALE & FEMALE ATTITUDES AS A BARRIER

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it in three ways:-

(a) discuss the specific questions set out at the end of the paper at the meeting to be arranged at your University/Institute for this purpose both in relation to your <u>own discipline</u> and your <u>institution</u> as such, and in the light of the research summary;

(b) raise any <u>other</u> aspects seen by you as directly relevant to the issues raised in this paper but not covered by the summary; and

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Attitudes a major influence

Our acquired attitudes are built up from our experiences and from the way in which we interpret these. They derive from "evidence" presented to us from which we construct what <u>we</u> see as "reality". Head (1984) describes an attitude in the context of science as an "underlying generalised construct". Certainly recent research in the areas of the psychology of sex differences, in vocational motivation and aspiration, and in achievement of adolescents, confirms this. That is, the influence of our attitudes and of other people's attitudes to us, does <u>underly</u> most of our decision making. From this underlying influence, we generalise, to see certain behaviour or goals as "normal" for our sex, or our ability, or our social background. Adolescents are particularly unwilling to indulge in behaviour not seen as appropriate for their sex or for their age or within their peergroup.

There is a well accepted sex difference, however, in the extent to which peergroup attitudes and attitudes of significant adults affect male and female students. In the primary years, boys appear to be more concerned with approval from peers, but girls with approval from adults, (Davie, Butler and Goldstein, 1972) while research into curricular sex differences in secondary curricular achievement suggests that with the onset of puberty, girls and boys alike become generally deeply concerned with peer group accreditation from both their own sex and the opposite sex. To the extent that teacher approval and support is seen to be influential, girls are however still seen to be more influenced than boys by teacher expectations, and by adult definition of their roles. Researchers have attributed up to 25% of variance in science achievement to how students feel towards what they are studying, the learning environment and their self concept (Bloom, 1976). Earlier research attributed a further 25% to the quality and type of instruction a student receives in terms of cues, reinforcement and encouragement to participate (Dollard and Miller, 1950).

Male attitudes to females in science and technology

Attitudinal barriers are widely held to be the most influential in holding back achievement, whether of girls, those from lower social classes, country children or migrants. There is now research evidence from different countries and different cultures, that boys in the upper primary and secondary years are increasingly hostile to girls' entry to certain subjects or disciplines, but not to others. (See also the Images paper in this series.)

Boys in schooling and males in positions of authority have been shown to assert that either

(i) boys are "naturally" cleverer than girls at maths or physics and should be given priority (the perceived biological factor) and/or

(ii) that scientific and technical subjects are more important for boys because they are needed for future careers; and that girls don't need qualifications for careers (the vocational factor) and/or

(iii) that certain subjects (maths, physics, technical drawing) are unsuitable for girls and are "unfeminine"; they have a male label (the territorial factor).

Hostile male attitudes have been found by researchers at primary, secondary and tertiary levels. A Sydney study of 1119 girls and 1158 boys in the 1970s, looked at the attitudes of 9-13 year olds. Among the assertions drawn from the children's own sayings and then empirically tested, were that

* boys are better at maths and science than girls
* boys are cleverer than girls
* girls would not make good engineers
* boys make better leaders.

54% of boys but only 5% of girls thought boys were cleverer. Threequarters of the independent school boys and half of the state school boys thought that girls would not make engineers, were weak and silly, and 77% of boys (but only 14% of girls) thought boys make better leaders (Phillips, 1975).

In the British project Girls into Science and Technology (GIST), boys recorded that girls who succeeded in science were "peculiar" (as well as not typically feminine) and that girls either weren't good at or were unlikely to be good at, science (Kelly, Smail & Whyte, 1981).

Other British research has found that in a 1984 national survey of teachers' attitudes to traditional and nontraditional choices, teachers of science, maths and technical crafts were the most likely to be opposed to altering the sex differentiation of the curriculum, and that more science teachers tend to believe that boys are more suited to and gifted in science, irrespective of the actual abilities of pupils in their classrooms.

Attitudes can operate adversely at tertiary level also. A Danish review of special efforts to increase women's enrolment to engineering, resulted in higher female dropout even after a significant initial increase. One reason given was that women students "are not taken seriously although they, to start with, have better marks (grades) than the male student on average. In spite of that they are often not regarded as sufficiently skilled technically to study at the place (technical university)" (Due-Billing and Bruvik-Hansen, 1983). The limited Australian evidence is conflicting on this, academic staff recording a supportive attitude to women students, and women students reporting, as might be expected, no problems in some disciplines to male mockery and harassment in others.

In an American study, Clark and Abron-Robinson (1975) reported a variety of perceptions by peers and lecturing staff of female students' capacity in engineering, including hostility by male professors to women undergraduates. Later American studies however, appeared to reflect some changes in the social climate since the mid 1970s, recording that minority women students tended to be more highly qualified and motivated, and therefore (implicitly) supported. Pressure from male peer students is still seen as more influential than adverse attitudes by male staff in Europe and in Australia.

Female attitudes

Some studies suggest that "traditional" women students (ie in disciplines which recruit more females) are often as hostile or critical to nontraditional women as men are seen to be. Mothers are as often reported as equally unsupportive to daughters wanting to enter surveying or physics or mathematics, as fathers. Much of this derives from embedded sexstereotypes about female roles. Some derives from out of date images held by parents about work in the technological professions.

The research literature on the alleged lower self esteem, self concept and confidence of women students, is now under some criticism for oversimplification. Where, however, female school or tertiary students are still consistently seen to be less confident or less vocationally ambitious, this has been mainly interpreted by researchers as strongly influenced by

(a) lower teacher expectation of girls; less teacher attention to girls;

(b) constant devaluing of girls' and women's capabilities by male peergroup school and tertiary students;

(c) negative advice or active discouragement by parents or careers advisers.

In a small (N=53) sample of Denver junior high school students, a simple structured interview asked eight questions, one of which was "what did the teacher do to make you like science more or less?". More males commented on direct help from the teacher, especially with experiments; females mentioned personality characteristics of teachers three times more often (McMillan & May, 1979). Other studies refer also to sex-differentiated behaviour by teachers (of both sexes) towards male and female students respectively in science classes. Other attitudinal issues are discussed in Paper 3 in this series on the Image of science and technology as a factor.

It would be possible of course to write off widespread reporting of adverse male attitudes as subjective and anecdotal, despite a growing body of serious research; or to see it as only a problem in schooling. Reports from students in tertiary institutions however, from counselling staffs, and from lecturing staff concerned about female underachievement or "channelling" into limited options, suggest that there is significant replication at the tertiary level of an early ingrained male hostility to females competing in areas seen as territorially male.

Males are also widely reported in research and in Australian studies of the status of women in tertiary institutions, as having more traditional attitudes to women's longterm role outside the home, than females. In the context of the WISTA study, several questions arise.

(1) What role can the senior staff in higher education institutions play in improving male attitudes of staff and students towards women's equal access to the male dominated disciplines?

(2) How can institutionalised attitudes be changed? Or change be accelerated?

(3) If women's access to physics, engineering and technology is more resisted by males, than to other science areas such as microbiology, chemistry or maths, can you account for this?

(4) Is there a role for tertiary institutions to play in presenting their disciplines as "sex neutral" and appropriate for women, to staff advisers and parents in the secondary sector?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 6

SINGLE SEX V. COEDUCATION

Discussion Paper 6 by Eileen Byrne and Elizabeth Hazel in the WISTA survey of ten Australian higher education institutions, 1986

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SINGLE SEX V. COEDUCATION

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it in two ways:-

(a) send Professor Byrne at the University of Queensland, with a concurrent copy to Dr Hazel at the University of New South Wales, a considered written response if you wish, either individually or as groups. In particular, written recommendations for possible action by higher education institutions or by Federal or State education authorities, will be welcome.

(b) raise any other aspects seen by you as relevant to the issues raised in this paper but not covered by the questions.

Single sex v. Coeducation - the problem

The debate about the relative advantages and disadvantes to girls and to boys respectively, of being educated in singlesex or mixed schools, dates only from the 1970s, from mainly British evidence. In the "popularisation" of the debate, assertions have become current which are not supported by much of the later, more scholarly and rigorous, research. The issue is considerably more complex than the current "received wisdom".

There are three main ranges of issues which have been raised. The first relates to girls' relative choices of and achievement in maths, science and technical subjects in relation to girls in mixed schools and to boys in both kinds of schools. The second relates to the role of single sex (post-school) colleges in helping women's achievement and progression in higher education. The third deals with the environment of single sex and coeducation in terms of girls' confidence, self esteem and vocational motivation, and with the apparently different ways in which teachers use language and discourse with girls and with boys respectively in mixed and in single sex environments.

In the subsequent educational debate, a number of assertions have moved to the status of strengthened hypotheses - some, but not all of which are significantly supported by subsequent research.

Hypothesis one : more girls choose or succeed in maths, physics and chemistry in 16+ exams and at Advanced Level (Grade 12), in single sex than in mixed schools.

Hypothesis two : more girls will go on to higher or advanced tertiary education in maths, science and technology from single sex than from mixed schools.

Hypothesis three : girls are more likely to acquire confidence and higher self esteem in a girls' school than in a mixed school.

Hypothesis four : that more girls will choose nontraditional vocationally-oriented courses (engineering, mining, metallurgy, surveying) from single sex schools or colleges; and fewer will drop out generally once enrolled from whichever type of school if in a single sex college.

Hypothesis five : that boys' domination of language and of teacher attention in the secondary years disadvantages girls in coeducational classrooms, discourages them to pursue "male" subjects like physics, maths and the technical crafts, and reinforces traditional sexrole course choices.

What does the research say?

(a) Girls' choices of and success in maths and science

There are a number of issues which have been raised in the decade since Her Majesty's Inspectorate (HMI) in England in 1975, published the first review of sex differences in mixed and single sex schools since the Borard of Education's 1923 report (DES, 1975; Board of Education, 1923). The HMI report suggested that in its survey of 10 per cent of all state maintained schools in England and Wales, "girls are more likely to choose a science and boys a language in a single sex school than they are in a mixed school" (DES, 1975, p.12), but that for prevocational and practical courses, "girls in single sex schools do not enjoy as wide a variety of these courses as do their contemporaries of either sex in any other types of school" (p.14).

The first general point which must be made, is that in England and Wales, in Australia, and in most European countries, the majority of single sex schools are feepaying, academically selective, private or independent, and middle class; while most mixed schools are comprehensive (all ability), state maintained, and are weighted overall with more lower middle class and working class children. Straight comparisons are invalid unless the data has been specifically controlled or adjusted to allow for

(a) a generally higher ability intake in the majority of single sex schools which are academically selective, and

(b) different social class intakes between types of schools.

The most recent research which has specifically controlled for these factors, tends to report minimal differences between types of school, after adjustment.

Wood & Ferguson (1974) checked out the data for 100,000 pupils entering for the Ordinary Level (Grade 10 equivalent) examinations in Britain. They looked at single sex and mixed schools across 13 subjects and concluded that girls in girls' schools appeared to have a slight advantage in most subjects; that girls only schools produced higher rates of female passes in physics and chemistry (than mixed schools); and that when schools change from single sex grammar to mixed comprehensive, the success rate of girls reduced and that of boys improved. It is not, however, clear whether they controlled for relative differences of intake.

Ormerod (1975) applied the Brunel Subject Preference Grid to 1204 pupils (518 boys and 686 girls) in ten single sex grammar, five mixed grammar and four comprehensive schools drawn from four contrasting regions of England. Overall, he found that single sex educated girls "have their preferences met by less satisfactory choices than do the boys ... the main weakness (however) is with coeducated girls" (p.265). His results on the Preference Grid led him to conclude also that attitudes towards teachers are likely to play an important mediating role in subject preferences, and should be included as a factor when interpreting sex differences between types of school.

Steedman (1983) questions some of the earlier conclusions about achievement in British single sex and mixed schools. With a research grant from the Equal Opportunities Commission (UK), she reviewed the findings of the National Child Development Study (a longitudinal study of over 14,000 people born in one week in March 1958). The data were reexamined to check out single sex and mixed secondary schooling and in summary, she found that "most differences between the examination results in mixed and in single sex schools are markedly reduced once differences in initial attainment and in home background have been allowed for". In relation to science, the NCDS reworked data, showed that while girls performed less well than boys in chemistry overall, there was very little advantage in girls' schools over mixed schools in girls' chemistry achievements. Similarly, despite a "very extreme" sex difference in physics enrolment and performance overall, girls' performance in relation to boys' was only marginally improved by being in a girls' school.

Steedman had been able to adjust the raw data for differential ability intake as between the types of schools, and (where appropriate) for social class. Sex differences in previously unadjusted scores showing slight advantages to single sex schools in achievement of four or more "good" passes (per pupil), then diminished to minimal after adjustment. Mostly, where girls in girls' schools retained a performance advantage, this was in relation to "high examination performance" (the high fliers). She concluded that the small differences were "not enough to suggest that single sex schools (or classes) would remove the sex differences in science performance (nor that mixed classes caused them)".

A review of the available evidence over the 1970s (Bone 1983), while including an overview of the examination success rate literature, raises wider issues. Bone's overall conclusion is that the research she reviewed found that the subject mixes taken by girls, their academic results and the "responses of schools to their more personal needs" have been more conditioned by the type of school (grammar selective, comprehensive all-ability, independent private) and its style (traditional or not), than by its single sex or mixed status. However, girls do appear to be a little more likely to look favourably at "male" curricular areas when educated with other girls than in mixed environments in adolescence, although Bone's review suggests that girls' schools are still not "notably active" in encouraging departures from sex stereotypes. Also, girls of very high ability in academically oriented schools were less likely everywhere to be as sex stereotyped. On the whole, Bone concludes girls in girls' schools do not generally do better in maths and physics than girls in mixed schools, but girls in girls' grammar schools did better. The single sex environment of itself does not have a significant effect on academic performance; only when single sex schools are also grammar schools. Even then the advantage is statistically quite minor. At the more qualitative level, a first issue is that while girls' interests were closer to those of boys when in single sex girls' schools, their choices were not necessarily so (Ibid, II 3.1 and 3.2).

Work at Chelsea College, London (now King's College) under Jan Harding's direction, has looked at entry and pass rates in both Nuffield and traditional externally examined science courses in the early 1970s. The project looked at sex differences, controlling both for single sex and mixed schools and for type of school (grammar, comprehensive and independent). The results were interesting in that while the pattern of passes for some science subjects for some examining Boards showed an apparent advantage to girls in girls' schools, the sex differences in pass rates varied within a subject (eg chemistry) either with different Boards or with different types of school (eg grammar, direct grant, comprehensive), apart from sex of school (Harding 1979 and 1981). That is, there was not in fact a consistent difference between subjects (eg chemistry across all Boards as distinct from physics across all Boards), nor a constant finding when sex status of school was matched with type of school. Harding later questions whether it is not teaching style and organisational style of the school, rather than its single sex or mixed status (Harding, 1983). Ormerod and Duckworth's review of a range of research dealing with attitudes to science concluded that boys and girls do appear to have generally different learning styles and to respond differently to various teaching strategies and teacher behaviours (Ormerod & Duckworth, 1975).

(b) Single sex colleges

There is some preliminary evidence that attendance at single sex colleges (postschooling) is seen as influential in the USA. How far it is the single sex environment, however, and how far the maturer age of the women concerned and the nature of their early programmes in colleges, is hard to identify from the published records. For example, St Mary's College, Indiana has developed a dual degree programme which enables women attending a single sex liberal arts programme to pursue an engineering degree in addition to their two year degree in humanities (or sciences). It is believed that the women "have an opportunity to develop intellectually and socially without competing with men for leadership" and they are seen to enter the male-dominated third year with increased self assurance and confidence (Aldrich & Hall, 1980). Smith College and the University of Massachusetts have a similar dual-degree programme in liberal arts and engineering and for three years, students take a balance of both (second to fourth year) with a fifth year only in engineering (Ivey, 1982). In both cases, women's participation in engineering in the host university appears to have increased.

(c) Single sex and mixed environments

The third area of controversy is about the learning environment. Research into the area of gender and language (what language is used, how adults talk to boys and to girls, how much attention they give each sex, etc) has suggested that (whether consciously or unconsciously), teachers of both sexes appear to treat boys and girls differently from each other in language, conversation and attention, and to treat girls differently when in mixed or girls only classrooms. Spender's work on gender and language leads her to conclude that females in single sex groups are more likely to use a cooperative form of dialogue, men a competitive one and that when the two sexes are together, the male competitive mode wins. Spender cites research to support the view that women prefer a balance of talking and listening and are more reluctant to interrupt; and that girls in mixed classrooms are socialised into ceding to male dominance in answering teachers' questions. Girls hence do not acquire confidence in debate.

Spender's work spells out convincingly the importance of language in "shaping our world" and in "classifying and ordering the world: our means of manipulating reality", (Spender, 1980). If her arguments have substance, the different performance of girls in teacher:pupil interaction in single sex and mixed classrooms is potentially significant in maths and science lessons.

However, the experiments in single sex classes in mixed schools have, perhaps predictably, produced mixed results. While some single sex experiments have produced temporary gains in girls' confidence and participation, both staff and girls are more often reported as accepting the need to change the much-reported male domination, aggression or mockery in mixed classes to a teaching and learning process which gives equal opportunity for both sexes to develop (Kelly, 1981; Smith, 1980; Rhyddercn, 1984). One survey reported girls as preferring single sex classes (DES/HMI, 1980). Of the girls who were asked how much they had enjoyed their time at school in the Fifteen Thousand Hours survey of London schools in the 1970s significantly more in mixed than in girls' schools recorded "quite a lot" or "very much" (Bone, 1983, p.111).

Australian implications

We do not have parallel evidence for Australia. More girls in Australia attend private schools proportionately, than in comparable European countries, but no hard data is available to support or reject these overseas data. It has been hypothesised that if these single sex differences in attitude, performance and participation in upper secondary classroom discussion and activity were replicated in Australia, they would be relevant to the first years of university work also because students from 17-19 years are frequently in schools in England, France, Germany and Denmark, but are in university or institute in several, if not most, Australian states.

Moreover, single sex colleges in Australia differ from their American and British counterparts in both intake and role. Both overseas models recruit from a wider range of social class, and the relevant (researched) ones include teaching as well as residence. One is not, therefore, comparing like with like. Nevertheless, the American experience of collaboration between single sex higher education colleges for women and Schools of Technology, Applied Science or Engineering, raises some interesting questions.

Questions which arise in the context of Australia and of WISTA, include:-

(1) Do institutions in fact have any evidence that proportionately more of their female intake in the nontraditional disciplines being surveyed come from single sex schools? Or could such data be collected? (Caution: this would not, of course, tell us proportions of age cohorts in schools, but might establish a prima facie case for further enquiry.)

(2) In disciplines where women are over 10% but fewer than 30% of the average class, does the pattern of Lecturer:student interaction support overseas experience that women lack confidence in oral expression or debate in mixed classes or tutorials? If so, in which disciplines is this noticed?

(3) For careers and counselling staffs and tutorial staff

Are you conscious of any difficulty in adaptation from a girls' school environment to a mixed university class or campus in the cases of women students who seek help or who are referred to you?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 7

CAREERS EDUCATION AND EDUCATIONAL AND VOCATIONAL GUIDANCE

Discussion Paper 7 by Eileen Byrne in the WISTA survey of ten Australian higher education institutions, 1987

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

As part of the WISTA policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

CAREERS EDUCATION AND VOCATIONAL GUIDANCE

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it by sending Professor Byrne at the University of Queensland,

(a) reactions to the specific questions set out at the end of the paper, in relation to your own discipline or profession within your institution;

(b) comment on any other matters raised in the research summary or otherwise, which you see as important and relevant to the influence of careers education and/or educational and vocational guidance on women's aspirations and access to science and technology.

DEFINITION

The meaning of careers education, of vocational guidance and of educational counselling, varies from country to country, from state to state. Theoretically, all such systems have at least one common aim, that of advising young people in adolescence, firstly of career opportunities suitable to their age, ability and aptitude, and secondly of the educational prerequisites (formal or non-formal) needed for these. In practice, careers guidance services are conceived and organised in very different ways - some primarily as psychologically-oriented curricular advisory services (France, Belgium); some as educational guidance given by trained teachers in schools (Denmark, Ireland); some as employment-based vocational guidance (F.R. Germany); and some as a joint service based partly in schools with trained careers teachers who work in turn closely with trained careers officers experienced in current work patterns and opportunities and based in the Employment Service (United Kingdom).

In Australia, guidance tends to be a more generic term, focussing on routes, opportunities, outcomes; a form of marketing. Counselling tends to be used of a more personal process on a one-to-one basis. But the existence of educational guidance and counselling does not necessarily include the concurrent existence of vocational guidance or counselling towards specific job outlets or occupational sectors. Historically, vocational guidance services have been provided by Commonwealth Departments of Labour. The 1985 Commonwealth review of careers guidance services in Australia identified criteria for guidance as needing to involve a <u>planned</u> orientation; needing to involve <u>flexible</u> orientation; needing to be responsive to <u>individual</u> needs; needing to be <u>relevant</u> (whatever that means) to future adult life; and needing to relate <u>accurately</u> to available occupations (Commonwealth Department of Education, 1985). Research evidence suggests, however, that these goals are not, however, reached for most students; and least of all for girls.

RESEARCH EVIDENCE

The inadequacy of careers guidance services in schooling systems has emerged in the 1970s as a widespread, cross-national and cross-cultural problem. A UNESCO expert meeting on Educational and Vocational Guidance for Girls and Women in 1976, criticised current systems as stereotyped, sextyped, out of touch with the real world of work and based on expectations of sexsegregated adult work roles (UNESCO, 1976). In the same year, an EEC report on the transition from education to working life criticised vocational guidance and educational counselling as "superficial and limited ... teachers are often expected to advise when they have little knowledge of any working life other than the scholastic one". Weaknesses common to most European systems and identified in the EEC report, were that the systems were optional and often bypassed; the personnel were too few and inadequately trained; services were provided too late to influence curricular choices; teachers and guidance staff were out-of-date; involvement of parents was minimal; guidance offered to girls was stereotyped and based on sexpolarised work expectations (Commission of European Communities, 1976, pp.46-48).

A specific study of the education of girls and women commissioned in the late 1970s by the nine Ministers of Education of the EEC, found that careers and vocational guidance across the nine countries surveyed was reported as too little, too late, sextyped and out-of-date (Byrne, 1978).

The <u>quality</u> of careers and vocational guidance is recorded as a problem in Australia, as overseas. A range of studies has consistently shown that careers guidance services use out-of-date knowledge of work and need closer relationships between school and occupational interests (Knight, 1977; McGaw et al, 1977; Stroobant, 1978; and others). It is also argued that guidance services reach students too late to be effective (Knight, 1977; Stroobant, 1978) and that the quality of guidance is particularly poor for female school leavers (Connell et al, 1975; Wright et al, 1978). In 1983, an evaluation of initiatives to change girls' perceptions of career opportunities, reported that in 1981 "the work of careers teachers, advisers or counsellors, as they are referred to in different States, showed that people who held these posts were not initially trained to cope with the problems of expanding girls' careers options (as distinct from boys), nor was the topic more than touched on, as one of many, during annual inservice" (Sampson, 1983, p.43).

The use of careers guidance services is equally in question. In Poole's study of 1600 young people aged 15-18 in Victoria in the 1970s, students were asked how often they had received vocational assistance from a variety of sources. Of this sample, 88.8% said they had received no advice from careers advisers (Poole, 1983). And indeed, some research suggests that in any event, students take more notice of parents, than of advisory services. A 1984 report on a national study of the attitudes of young Australians, concluded that "when making important decisions about employment or education, most notice is taken of parents, and more so of mother". Within the sample, "more young women indicate that they take notice of their mothers than their fathers, and the reverse applies among young men". Fewer than one quarter of high school students nominated careers advisers or teachers as influential, and overall, "careers advisers, other relatives and teachers emerged as lesser influences, at below the one in ten level" (Department of Sport, Recreation and Tourism, 1984, pp.40-41).

On the other hand, in a Western Australian study of 704 school students aged 16 to 17, researchers looked at differences in vocational aspirations in relation to sex, social class, mental ability and home environments. The researchers concluded that parents and teachers (in that order) were the two most important intervening variables (Punch & Sheridan, 1978).

An Australian Federal review reported on careers guidance and counselling services in Australia in 1985. As with the EEC's overview, the Commonwealth found that assumptions underlying different State systems "differ according to systems and circumstances, and are not necessarily consistent or coherent". The reviewers found that "many guidance personnel work almost entirely within the framework of the school curriculum" and that as a result the guidance was educational rather than occupational. Above all, the review concluded that there was urgent need of a retraining drive: "there appear to be few 'experts', that is personnel with qualifications, experience or training which is beyond the rudimentary .... a background in psychology is probably not essential for effective careers counselling" (CDE, 1985, p.22). What was needed, it was argued, was personnel who can use guidance materials <u>through effective intervention to secure positive outcomes</u>.

<u>A NEGATIVE INFLUENCE?</u>

Some researchers, and some respondents from the ten WISTA survey institutions, suggest that, furthermore, careers guidance services actually have a negative effect on girls' aspirations and career choices. An American evaluation of attempts by vocational schools to overcome sex stereotyping in vocational schools in the 1970s, found not only that teachers' attitudes to girls' entering non-traditional areas were stereotyped and discouraging, but that school counsellors' attitudes were negative to the point of repression or direct discrimination. They discouraged non-traditional courses, "probing to be sure the interest was serious" and rejecting girls for technician level engineering on the grounds that "one female in the workshop might be disruptive" (Lewis, et al, 1976).

Another American study concluded that guidance counsellors in high schools believed that courses in maths and science should be encouraged for males rather than females (Casserly, 1975, p.30). There are many other such studies which record similar conclusions in a range of countries and cultures.

In Australia, the Head of Materials Engineering at a University, wrote in response to an earlier enquiry into Women and Engineering (Byrne, 1985, p.45), that

> *"I can confirm my belief that the key disincentive for women to undertake engineering lies in the misinformed and prejudiced advice given by careers personnel which includes teachers and parents. In this latter regard, I well recall a mother bringing her daughter to see me some 10 years ago to, in effect, beg me to persuade the girl not to undertake engineering. The same daughter did come to the University, completed a Materials Engineering degree, and I happened to meet her last week at a conference in Britain where she was representing her Melbourne-based firm!"*

In the 1985 and 1986 tape-recorded WISTA group discussions with Deans, Professors, Heads of Schools and other senior academic and professional staff in the ten WISTA survey institutions, a significant number of those from the most male-dominated disciplines (engineering, physics, mining, geology), commented on careers guidance. One consistent report across many institutions was of school teachers and careers guidance personnel actively discouraging girls from entering non-traditional areas of science and technology even when the girls were originally motivated. Their minority female undergraduates were frequently reported as achieving engineering, mining or physics despite careers guidance, not because of it.

There is a growing consciousness that it is difficult for young people to develop realistic aspirations about their choice of work, in a vacuum. They need an accurate and understandable "framework of possibilities". (See, for example, Super, 1975.) This implies in turn an accurate knowledge of different occupational sectors and their prerequisites, on the part of the advisers, and a matching of aspirations and expectations on the part of the student. The available evidence (of which only a brief mention is made here) places seriously into question, whether the present structures, quality and character of vocational guidance, in any way challenges current sexrole stereotypes - or indeed, whether they do not reinforce them.

POLICY IMPLICATIONS

The evidence is conflicting in one important regard. Some research studies suggests that careers education and guidance act as a negative factor, but others that whatever its quality, the school careers and guidance services are irrelevant because young people either do not use them or they take no notice of the guidance or they are more influenced by parents.

Clearly, many other factors affect career aspirations. For example, socio-economic status (SES) of parents and family is seen to affect not only level but type of aspiration, higher SES being correlated with more advanced or less traditional aspirations for women (McLaughin, Hunt & Montgomery, 1976). A study of 2,495 Pennsylvania eleventh grade school students in 1968, concluded that while "*academic achievement had a stronger direct effect than socioeconomic background on occupational ambition, ... the total effect of socioeconomic background was greater than the total effect of academic achievement*", and that effect of both is less direct for girls than for boys (Marini & Greenberger, 1978). But we cannot affect socioeconomic status by policy mechanisms, whereas we could in theory attempt to change the educational environment, in line with Farmer's finding that high achievement motivation and career choice were significantly associated with perceived support for career goals in the school and community environment (Farmer, 1980).

The policy issue which faces both secondary and tertiary institutions most centrally is whether, given the apparent consistent and cross-national/cross-cultural research evidence that careers education and guidance not only does not advance girls' wider career choices but actually limits them, we should continue to support a service which fails 51% of the school population. Can the service be altered, improved and be made non-sexist? What evidence is there that effective change is achievable in the mainstream services?

Questions to be addressed include:-

(a) Would the aspirations of girls towards science and technology in fact be improved by the removal of the careers education and guidance process from schools altogether?

(b) Alternatively, are the present school based services perceived to be capable of change and improvement to become more accurate in their knowledge of scientific and technological occupations, and to become non-sexist in impact?

(c) If the answer to (b) is yes, what are the practical steps that can be taken, given the research evidence that over the last two decades, attitudinal change does not seem to have become noticeable widespread?

(d) What priority in resource-allocation should be given to attempting to improve careers education and guidance? How should we use scarce resources for most effective improvement in careers guidance?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 8

MATHS AS A CRITICAL FILTER

Discussion Paper 8 by Eileen Byrne
in the WISTA survey of ten Australian
higher education institutions, 1987

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MATHS AS A CRITICAL FILTER

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MATHS AS A CRITICAL FILTER

This paper does not in any way set out to review the wide range and complexity of issues which have been researched in the area of sex differences in mathematics in terms of options, performance and achievement. A later specialist WISTA policy report on women and maths will be produced in 1988 drawing on the evidence of the policy review strand.

This paper sets out to address the problem raised by the particular pattern of female enrolments in secondary and tertiary mathematics in Australia, and the way in which this acts as a critical filter to "sieve" girls out from the scientific and technological disciplines. The paper also raises questions about the role of higher education institutions both in changing policy and in providing remediation programmes.

THE CRITICAL FILTER EFFECT

In an earlier study of women and engineering (Byrne 1985), Heads of Departments in tertiary institutions who responded to the enquiry, cited inadequate preparation in maths as one of the major critical filters. Returns from Monash, Newcastle, Sydney Universities and the University of New South Wales all spoke of either inadequate school preparation, or of the difficulty which women students experienced with first year physics and maths.

Maths in Society (replacing Social Maths) is not suitable for tertiary entrance. Maths I is a prerequisite for Maths II. Maths I includes two calculus units, probability and statistics. Maths II includes matrices, vectors, mechanics, and a third advanced calculus unit. Queensland ASAT records show Maths II students (both sexes) to be consistently more able than Maths I students.

In New South Wales, the parallel figures are:

	Female %
All maths students	51
Maths in Society	58
2 unit Maths	54
3 unit Maths	40
4 unit Maths	29

2 unit Maths is designed as a general course and is only suitable for tertiary Maths being taken as a minor discipline. 3 unit Maths is needed for tertiary Maths being taken as a major, or for tertiary physics or engineering. 4 unit Maths is of a higher level than 3 and tests for "a high degree of understanding of algebra and calculus".

In Victoria, the differentiation is sharper:-

	Female %
Group 2	
Business Maths	58
Commercial Maths	50
Maths at work	55
Group 1	
General Maths	53
Pure Maths A	33
Applied Maths B	29

Maths A (pure) covers mensuration, probability, functions and calculus. Maths B (applied) covers functions, calculus, linear algebra, vectors, complex numbers, analytic geometry.

In South Australia, the filter effect is the same but the pattern of courses different again.

	Female %
Maths IS	52
Maths I	33
Maths II	33

Maths IS (equals one Maths subject only) is an alternative to Maths I and II and is not recommended as a pre-tertiary subject. Maths I and II are both seen as necessary for tertiary physics, engineering or tertiary Maths. They work as a double major at Grade 12 and are complementary. Unlike the New South Wales 3 unit and 4 unit which are different in level and standard, the South Australian Maths I and II are complementary and of the same standard.

In Western Australia, the pattern of courses is similar to that of South Australia.

	Female %
Maths IV	59
Maths I	52
Maths II	32
Maths III	32

Maths IV is not designed for tertiary entrance. Maths I is meant to provide for general tertiary entrance and includes algebra, trigonometry and statistics but excludes calculus. It is less advanced than II and III.

Maths II and III are a double major, are complementary and include algebra, trigonometry, analytical geometry, statistics and calculus.

IMPLICATIONS

The Australian secondary Maths data supports the concern of Deans and Heads of Schools, and the findings of earlier research (including major studies not cited here for reasons of space), that the filter effect operates as much within mathematics in secondary education, as between Maths and other subjects. In Queensland, the drop in female enrolments from Maths I (43%) to Maths II (27%) is very significant; girls are only one quarter or so of those taking the matrices, vectors, mechanics and third advanced calculus elements at Grade 12. New South Wales shows a similar falling off between 3 unit (40%) and 4 unit (higher algebra and calculus)(29%). But 3 unit in New South Wales is allegedly enough for tertiary physics and engineering, whereas Queensland Maths I is not.

The sex differential in Victoria is less marked. Pure Maths (33%) and Applied Maths (29%) recruit very similarly although the different content at Grade 12 is almost polarised. But while the sex differential is less marked, the proportional outcome is the same - only 29% of candidates taking linear algebra, vectors, analytic geometry being girls. South Australia and Western Australia show a slightly different pattern again - in both States, two complementary Maths subjects are both seen as essential for tertiary physics and engineering (and in South Australia, for tertiary Maths). The sex differential is between general and pretertiary Maths, not within pretertiary Maths, but again, girls are only one third (not one half) of those taking calculus, analytic geometry, advanced algebra.

CAUSES?

A later paper will deal more fully with the range of causes which previous research suggests may account for these patterns. It could be argued that until we know the true causes, we cannot produce effective remedies. The medical field, however, produces a useful analogy in that we have been able to produce very effective remediation (rather than cure) well in advance of our level of understanding of root causes, in a number of fields.

Early theorists attempted to argue that the sex differences in Maths performance (irrefutable) were due to universal (innate) female incapacity, and if one held this view, there would of course be no case for attempting remediation. Among significant studies which reject this genetic theory, the reports commissioned by the American National Institute of Education (NIE) to study maths avoidance in female students and to advise on policy changes, challenge the "female incapacity" theory (Fennema, 1977; Sherman, 1977; Lynn Fox, 1977).

Others have written of "maths anxiety" (notably Tobias, 1976 and 1978) and in a more recent article, Tobias and Weissbrod (1980) review maths anxiety intervention programmes with some concern that "practice is moving ahead of theory and experimental research. Viewed negatively, this could produce careless and irresponsible 'maths cures' " (p.68). In either event, this blaming-the-victim approach implies a policy of intervention programmes to remove the negative attitudes; unless we regard Frank Besag's latest work at Wisconsin as transferable and delete maths anxiety as a female cause, altogether. Besag and Wahl found no sex differences on maths anxiety or self esteem in a sample of some 7,500 students (Holden, 1987).

Others blame not the students, but school teacher attitudes and practices. That teachers do, in fact, (whether consciously or not) treat boys and girls differently in classroom interaction is well documented. In Becker's (1981) study of geometry teachers, teacher-initiated processes were weighted in favour of boys, who received more time and encouragement, attention and reinforcement. Brophy and Good's earlier (1970) study had confirmed that boys received more feedback and evaluative comment "both absolutely and relatively" and saw the teachers' different expectations of boys and girls as self fulfilling prophecies.

The image of maths is cited by some, either in terms of its perceived usefulness vocationally (Armstrong & Price, 1982) or its perceived sex-appropriateness (Leder, 1976; Armstrong & Price, 1982). Yet others argue that the whole issue centres not on female incapacity or inferiority, but on a different female approach to spatial development.

But whatever the causes, Australia faces a crisis in mathematics education which cannot wait for a complete understanding of the meshing of poor teaching, sex role stereotyping, out of date careers guidance, and influences on adolescent motivation and aspiration. One question facing us is how to invest scarce resources the most effectively in swift and effective remediation.

THE ROLE OF HIGHER EDUCATION INSTITUTIONS

Research into the processes of institutionalised schooling over the last 50 years or so in a range of countries, suggests that changing the ecology and practices of schooling is a slow, costly and largely ineffective process. Research and intervention programmes in schools remain at the pilot level and are rarely mainstreamed. The very fact, moreover, that the same patterns of sex role stereotyping, sex differentiation of school teacher attitudes and practice, sexpolarity of subject choice and sex differences in aspiration and achievement, are identified in research into schooling in the late 1970s and 1980s on almost the same scale as in the late 1960s, places into question the capacity of the schooling system to adopt organic change.

By contrast, special intervention programmes designed to top up missing maths, physics, technical skills in the USA, the UK, in Sweden and Denmark and in FR Germany, and which have targeted special groups at the post-schooling stage, have proved to have extremely effective and relatively swift returns for investment. In one American review of over 300 projects to increase the number and status of women in science, maths and engineering, a significant number were located in tertiary and higher education institutions - funded jointly by Federal aid and from the institutions' own funds (Aldrich & Hall, 1980). The (FR) German schemes which operate across all Länder and which have increased women's recruitment to scientific and technical training by very significant proportions, are also targetted at the late adolescent and young adult years and carry substantial Federal (systematic) funding.

It is not here argued that we should not, of course, work at longterm programmes of improved mathematics education in schools, but that this - if achievable - will not affect tertiary recruitment for many years and that we cannot wait to produce Australia's missing tertiary mathematicians, physicists and engineers. Concurrently with a long term programme to attack the schooling issues, Australia needs a mathematics remediation programme which will target in particular the female school leavers and young women who the WISTA data show to have missed out on those particular elements of maths needed for physics, engineering and technological disciplines. This would also apply, of course, to any male school leavers who have equally suffered the critical filter effect through poor curricular or vocational guidance.

However, the evidence from research in different countries into the aspirations and expectations of young people, and into patterns of curricular choice, establishes that in most (if not all) cultures, more young males will choose subjects for vocational or "useful" reasons (whether or not they like the subject). By contrast, research suggests that more young females choose through liking and interest. Clearly, there are significant exceptions (correlated with the minority enrolments in disciplines seen as non-traditional for each sex), but the generalisation holds.

In the 1985 and 1986 WISTA group interviews, the issue of maths as a critical filter was raised. Academic staff were asked, where relevant, how they saw the role of higher education institutions in providing for bridging courses; topping up courses; or late entry to allow for study of missing elements in maths in the higher education institution. (See also the Prerequisites paper in this series which raises the issue of prerequisites versus corequisites.)

Opinions were divided and academic staff adopted three main positions -

(a) Some felt the problem was a schooling one; that it was not the task of Universities and Institutes to take on any remediation of lower level work; and that the policy issue involved was not one in which higher education had a role.

(b) Others considered the matter urgent and critical if the problems of female under-recruitment to certain areas of science and technology were to be solved. They regarded the urgent <u>systemic</u> provision of bridging or topping up courses or of special maths remediation programmes as a priority policy issue. But they saw this as the task of TAFE colleges and did not wish to see higher education resources devoted to this.

(c) A third view was equally expressed. These staff adopted the main stance outlined under (b), but considered it essential that those programmes aimed at topping up the kind of work needed for higher education physics, engineering, applied maths etc, should be taught by higher education staffs in their own institutions. They either did not (rightly or wrongly) feel the confidence in the TAFE system as a whole, to teach the "right" elements at the appropriate level. Or they considered the students would benefit from the more integrated approach of remediation programmes specifically designed as pre-physics, pre-engineering etc.

The corollary expressed by all who took this view, was that Universities and Institutes should receive special supplementary Federal funding for this essential work.

The British Cockcroft Committee on Mathematics teaching in schools, also saw it as essential that higher education institutions played a more major role in the inservice education of school teachers. The Committee, however, recognised that time spent on this was seen by academic staff as "to the detriment of their academic careers, because those responsible for making appointments do not value experience gained during inservice work as highly as evidence of published work. If this is the case, we regret it." (para 742). The Committee recognised this as a sharper dilemma in relation to promotions but recommended an extension of consultancy work in inservice education not only because of its benefit to schools. It "also enables those who work in training institutions to gain up-to-date and first hand knowledge of the work that is going on in primary and secondary classrooms" (para 743).

Such a policy would also have implications for higher education staffing policy in general.

Questions which arise in the context of WISTA, include the following, to which you are invited to respond.

(a) Should higher education institutions develop special programmes of mathematics remediation to provide missing elements of maths not taught or inadequately taught in schools?

(b) If the answer to (a) is yes, what do you consider the scale of the provision your institution would need to provide for your State/subregion? (eg estimated annual targets for students and extra staff).

(c) If the answer to (a) is no, should special remediation programmes be developed elsewhere in the education system, and if so, where?

(d) What priority would you recommend should be given to this provision against other existing or new needs in higher education, given increasingly limited financial resources? Should the provision be met wholly directly from special Federal sources; or from Federal/State resources; or partly from the institutions's own budget?

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EMB/11/87

WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 9

WOMEN'S SUPPORT NETWORKS

Discussion Paper 9 by Eileen Byrne in the WISTA survey of ten Australian higher education institutions, 1987

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

As part of the WISTA policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

WOMEN'S SUPPORT NETWORKS

as a potential factor of influence.

Colleagues are invited to read this paper and to respond to it by sending Professor Byrne at the University of Queensland,

(a) reactions to the specific questions set out at the end of the paper, in relation to your own discipline or profession within your institution;

(b) comment on any other matters raised in the research summary or otherwise, which you see as important and relevant to the influence of careers education and/or educational and vocational guidance on women's aspirations and access to science and technology.

WOMEN'S SUPPORT NETWORKS

This paper sets out to raise the issue of the role of women's support networks as a possible positive factor, as much in the retention as in the recruitment of women to non-traditional disciplines such as engineering, mining, surveying and computing in higher education.

It should be said at the outset that the reporting on this issue in Australian and overseas literature is, to date, uneven, incomplete and inconclusive. We do not yet have a firm body of research and evaluation which will provide any decisive basis for action. Nevertheless, the constant increase in women's support groups and the widespread reporting of their perceived importance, makes further exploration relevant.

WHY WOMEN'S SUPPORT GROUPS?

There is nothing new about the principle of sexrole-based support groups or of informal but effective networking. The unstructured old boys' networks which operate between boys' schools, specific colleges or universities and sectors or firms in industry, which the British Public School system has brought to a level of considerable if discreet sophistication, have operated in Britain and America for some two centuries.

Professional Associations of one kind or another in professions like law, medicine, engineering, have operated since the Middle Ages. They have been based on male-only membership until very recently (the 1890s for a rare few; the 1920s or 1940s for others) quite simply because secondary and higher education for women as such, available first to boys from the Middle Ages, was only opened up to women in the late 19th century and early 20th century.

Necessarily, in every field which women subsequently entered for the first time, they have therefore been in a small minority. The issue increasingly under debate, is whether it is possible for any minority to move into an organisational structure which has a dominant culture different from that of the new minority, without interim special support in the early phases of development. It is this which has principally given rise to an almost exponential increase in women's support networks in the 1970s and 1980s.

The purpose and rationale of women's networks and women's groups can differ considerably. Some have been formed specifically to provide support training programmes and services or scholarships for minority women in disciplines new to women. Others have set out to replicate for girls, the male old boys' networks and informal systems which operate between schools, higher education and industry for boys. Yet other networks are a general reaction to the widely reported but imprecisely defined alleged female "low self esteem", "fear of success", (the research base for these is highly questionable). They also set out to provide sisterhood support to match or counteract male mateship, for women who feel isolated.

Almost all of them have their roots in two main theories which form part of the framework for this study: role modelling theory and critical mass theory. Almost all of the well established women's specialist groups and networks are reported as setting out to provide female role models or to strengthen the role modelling process in disciplines such as engineering, mining, construction, and latterly, computing. And many seek to strengthen women's confidence and increase retention rates by creating a larger "critical mass" from the minimal numbers of minority women scattered in male-dominated areas, linking them in a coherent and strongly supportive cross-disciplinary grouping.

THREE BROAD TYPES

The range of women's support networks which have operated in Australia and overseas over several decades, fall into three main categories. First, and the oldest, are the formally-constituted discipline-based groups based in the professions and, latterly, in higher education institutions, like the British Women's Engineering Society (1919), the American Society of Women Engineers, the French Association des Femmes Ingénieurs, and later similar groups in mining, aerospace and computing. Secondly, come the formal or informal networks of minority women working or studying specifically in areas seen as non-traditional for women, which operate within institutions or organisations. A leading example is the Aerospace Women's Committee in America which helps women engineers to use company opportunities better "by briefing women on the skills needed, giving them practical organisational and managerial experience and putting them in touch with project managers" (Truxal, 1983, p.61). Thirdly, are the more recent networks which cross disciplines and work areas and work horizontally, as it were, in institutions and organisations to support women in confidence-raising, improving interpersonal management or leadership skills and learning to cope with male culture and male-dominated environments. The Women's Opportunities Network at the University of Georgia, established in 1979, for example, works to support non-traditional students of all kinds (including mature women returners) and has in membership women from academic sectors, health, counselling, continuing education, career planning etc. The network is of women in the power structure who work in committees and subgroups to support others (Copas & Dwinell, 1983).

RESEARCH EVIDENCE: TYPE, ACTIVITIES, OUTCOMES

(a) Specialist groups

The British Women's Engineering Society (WES) was founded in 1919 and developed by Caroline Haslett ("a screwdriver in one hand, a bracelet on the other", Messenger, 1967, p.30). Its prime aim was and remains "to enable technical women to meet and to facilitate the exchange of ideas respecting the interests, training and employment of technical women" (Ibid, p.31). Its aeronautical section was founded in 1932, and with cosponsors, founded a Memorial Scholarship Fund to fund professional flying training for women, after the death of Amy Johnson in 1941. This led in turn to the British Women Pilots Association (1957). Today, WES provides a significant source of women engineers who work with careers educators and with projects to encourage female school leavers to enter careers in engineering and technology. The WES works with schools, with higher education institutions and with industrial training boards, sometimes through its Regional Groups.

The French Cercle de Femmes Ingénieures (CEFI) is less involved with local support activities, but has played a leading role in sponsoring surveys and research into the problems and profiles of women engineers. Working with the mainstream profession, the CEFI has been seen as an important influence in increasing women's proportion of engineers to 15%, 65% of whom were under 35 in 1982 (CEFI,1982).

In America, the Society of Women Engineers (SWE) is not only well-established, but works across the States most actively with higher education institutions, high schools and industry to increase female enrolments to engineering. In none of the reported evaluations or research reports of projects set up to encourage women to enter maths, science and technology, (Aldrich & Hall, 1980; Byrne, 1985), is it possible to separate the work of the SWE from other factors to assess its significance. It is, however, widely reported as perceivedly influential. For example, Frohreich surveyed 130 large engineering schools in the early 1970s to look at measures to increase female enrolments to engineering and in particular, retention rates. Among seven listed approaches seen as common and influential, "encouraging students to form student sections of the Society of Women Engineers or some other similar local (professional) organisation is one common approach" (Frohreich, 1974). It should be noted here that American Engineering Schools are very large: numbers from 500 to 1,500 are not uncommon.

Staff at Purdue University, where recruitment of women engineers has rocketted, report the work of the Society of Women Engineers as of inestimable value. The University has a student chapter of the SWE which telephones every high school girl accepted into engineering in advance, and offers help and advice. Chapter members contact new women students on arrival on campus, arrange social events to strengthen networking; and the SWE gives awards for women engineering students for "scholarship, leadership and activities". The Purdue SWE has issued a useful brochure with resumés of 400 women engineering students to companies, which helps both vacation placements and final placements. (The sales make it not only self-financing, but it subsidises other SWE projects.) The SWE also works on vacation summer placements for women students. The SWE is regarded as "an essential resource" (Daniels, 1982). A decade ago, Sproule and Mathis regarded the establishment of a student chapter of the SWE as one of eight well-accredited strategies for what they describe as "proven techniques used to attract women to engineering". They list a wide range of similar SWE activities, including the University of California Chapter which sends letters to women applicants to engineering about scholarships.

Women in Mining in Denver, Colorado, works through elementary and high schools to convince males as well as females that women can have a successful career in mining. They have also established scholarships for women from low-income families to train for mining.

The Association of Women in Computing was the result of an initiative from the IEEE Computer Society at the (American) 1978 National Computer Convention. The founders were a group of women who went to many national meetings and "felt alone .... they weren't serving on conference committees, they didn't have contacts, they felt they needed an 'old girls network'" (Truxal, 1983, p.61). Some members saw the first task of the Association as helping women in computing "gain credibility and visibility, develop their professional skills and make real contributions to their corporations so that they can get the positions of influence" (Ibid, p.62).

The specialist women's groups are seen as having very much a dual role - helping female school leavers into higher education science and technology, and supporting those who achieve tertiary study.

In Australia, the Institute of Engineers Australia (IEA) has a Women's Engineering Group, and a Regional WEG has been operating in both New South Wales and South Australia for some time. The latter, aims particularly to help women in engineering to meet and correspond and to improve women's access to further training and employment, and "to provide personal encouragement to women pursuing engineering studies". Groups also exist of Women in Architecture and Women in Construction. It is not clear how far these follow their UK and American counterparts in working actively in higher education institutions.

(b) Institutional networks

Information about institutional and non-formal networks is less readily available. What is known, is equally variable. The University of Georgia's Women's Opportunities Network sees itself as an active provider of special services for non-traditional women. Its activities have ranged from special orientation programmes for targetted groups of women students, to special information packs about financial aid, scholarships and loans, (particularly for mature age students of whom the majority are women), and a general support service which trains up informal support groups operating in the student body (Copas & Dwinell, 1983).

In Australia, the institutional network principle has developed later than in Europe and America. A later WISTA research report will report fully on the position in the ten survey institutions. We note here that they vary from the informal Women in RMIT group which is open to all women in the Institute and which acts as an unofficial consultative voice for women staff and students, to the University of Queensland's Queensland University Women's Association (QUWA) which, inter alia, runs special lecture programmes for the wider University community on relevant issues as an attitude-changing process, and has formal consultative status. All of the recorded institutional groups or networks appear to have a declared rationale based on an implicit acceptance of the current received wisdom that:-

(a) Women need female role models and women's networks and special groups provide a useful source of these.

(b) Women's retention rates are thought to be better if they see themselves as a "critical mass" and not as isolated pioneer untypical women. Women's networks are seen to help develop a sense, or an actuality, of a stronger critical mass in male dominated areas.

(c) Many, probably most minority women will experience some lack of acceptance from male peers in areas where the discipline is almost entirely male in recruitment. This may range from social exclusion or becoming the target of jokes or comment, to overt hostility or harassment. Women's institutional networks are seen to provide help to women students and minority staff in learning to cope with these where they occur.

DISCUSSION AND IMPLICATION

In the 1985 and 1986 rounds of WISTA group interviews of Deans, Professors, Heads of Schools, Careers and Counselling staffs, and Equal Opportunity staffs, both evidence and attitudes range widely, and in some regards, were highly contradictory (as might be expected). Reasons for this are discussed below, but it should be noted that the Australian debate replicates conflicting stances recorded in overseas literature.

For example, Connolly & Porter conducted a major survey of factors which supported the recruitment and retention of women students in engineering. They rated two factors to be widely important in retention, or what they call growth - maintenance, or continued increases in recruitment. Firstly they cite "integration of women into campus life". Some respondents considered that women's groups hindered integration; others that, on the contrary, they provided a support advisory service to help women to learn the techniques for integration (getting on committees, "learning the language", becoming visible without becoming obtrusive) (Connolly & Porter, 1980).

While some respondents saw positive results from having an identifiable focus in a higher education institution to help the development of women minority students, other Deans were suspicious of overemphasising concerns for women and preferred special staff to be placed in the mainstream, for example in the Dean of Students' Office. Connolly & Porter report some Deans who noted that "women students were suspicious of women-oriented organisations such as the Society of Women Engineers, preferring to get involved in existing chapters of professional societies oriented to their discipline" (Ibid, p.826).

In the WISTA group interviews, Deans of Engineering tended to report that their women students on the whole were not sympathetic to Women's Engineering Groups ("I'm an engineer, not a woman engineer"). It is, however, important to recognise that women engineering students in Australia range from 3%-8% of the enrolments in most disciplines, and that they are frequently reported to be relatively more able students, and almost without exception, middle class. It is reasonable to suppose that women who have already overcome barriers to enter the discipline (see the concurrent Careers Guidance paper in this series) are less likely to need special support: they are already likely to have become more assertive, decisive or confident. They should not be seen as a typical group from whom to generalise.

And, indeed, concurrently in the same round of WISTA interviews, other staff referred to women students who had, in fact, needed counselling and support in a minority discipline. The woman engineer who wrote that "*the whole image of the beer-drinking, women-chasing engineer at university struck me as being really juvenile, and it was very tiring. I am not surprised women drop out because of that - you need a lot of determination to get through*" (Engineers Australia, 2.6.78), had her 1980s counterpart in several of the WISTA survey institutions, in 1986.

Deans and Heads of Schools and representatives of maths, physics and chemistry, reported less feedback of perceived need for support, than academic staff from mining, metallurgy, engineering and surveying. Computing staff did not see their discipline as "male", although female recruitment to computing is highly variable across the WISTA institutions and overall, women remain in a minority.

But by definition, if some women minority students are in fact receiving at worst male hostility or mockery or excessive teasing, to the point of harassment, and at best an implicit exclusion from a "normal" world in which rugger, beer and male jokes dominate, they are probably less likely to speak of these to the male academic staff who lead their discipline. And the evidence that there is a continuing problem in some disciplines tends to come from staff involved in counselling, in existing women's networks, or who themselves recognise the phenomenon of sexrole stereotyping as a still active one.

Thus, it is simultaneously true that some women students benefit from special and identifiably female support, and some may reject this as continuing a differentiation which is unhelpful. It also appears more useful in some disciplines than in others at the specialist level.

The Queensland WISTA team has completed a review on role-modelling theory and a full report will be included in the first Research Report to be circulated early in 1988, also using the 1985 student and staff data from the ten survey institutions. At this stage, it can be said that the evidence for suggesting that female role models increase recruitment or retention is at least suspect and empirically weak, if not unproven. Any case for using women's support networks as a policy tool based on this theory, and on their role modelling activities, is questionable.

More relevant in many respects, is the encouragement of the mentor role. When Truxal interviewed Esther Mayfield, President of Mayfield Engineering in California about what Mayfield described as male-female antagonism, she saw key decisions as made "*not on technical questions but on politics and the olds boys' network. It's hard for women. They just don't have that ... I think what I've been missing in my career is a mentor, someone to watch, and see how they handle a situation and learn*" (Truxal, 1983, p.61).

The processes and activities described have, overseas, taken place both in the professional sector and firms, and in higher education. Australian initiatives are less developed. Are the overseas models transferable? Is the investment of time and energy of the few women who have achieved in science and technology in this form of support to other women, usefully invested?

Questions relevant to WISTA and to the formation of future policy, and to which responses are welcomed, include:-

(1) Are you aware of a specialist women's group working in your discipline (eg Women in Computing, Women in Mining etc) either in the profession or in the institution, and if so, what do you see as its usefulness in helping women's recruitment or retention?

(2) Are you aware of any wider women's support network in your institution which helps women students in non-traditional disciplines? Do you see it as potentially helpful or not, in strengthening women's retention rates?

(3) Do you see women's support networks or groups as a helpful interim policy measure to be strengthened? Or as accentuating the problems of integrating women into a non-traditional discipline and not, therefore, to be encouraged? Can you say why?

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WOMEN IN SCIENCE & TECHNOLOGY IN AUSTRALIA (WISTA)

PAPER 10

THE IMAGE OF SCIENCE

Discussion Paper 10 by Eileen Byrne in the WISTA survey of ten Australian higher education institutions, 1987

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As part of the WISTA policy review of ten higher education institutions in Australia, the research team is seeking reaction from academic and professional colleagues, in five Universities and five Institutes of Technology to the major findings of established research on a number of factors held to be influential in helping or hindering women's access to and progression in science and technology. This brief paper deals with

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(b) comment on any other matters raised in the research summary or otherwise, which you see as important and relevant to the influence of careers education and/or educational and vocational guidance on women's aspirations and access to science and technology.

THE IMAGE OF SCIENCE

This paper sets out to look at the influence that the image of science plays in acting as a possible deterrent to female enrolment to scientific and technological disciplines. As with other papers, this brief resumé does not set out to deal fully with the issue, but rather to deal with those aspects in which higher education may have a role. This is principally in the areas of influencing the "construction of the discipline", and in shaping or altering its marketing.

There are three aspects to the question of image which previous research have highlighted as relevant. These will be discussed in more detail in the forthcoming Research Report, and here, only the main issues are selected in relation to the role of higher education institutions.

Firstly, disciplines have acquired sextyped images of ascribed maleness, or as suitable and appropriate for women, with relatively few emerging as sex-neutral. Within the male:female image, emerges a further subdivision. Some disciplines are seen by boys as beyond girls' capacity; girls can't do maths or physics. Others carry a label of unsuitability. Girls shouldn't do surveying or engineering.

Secondly, research in the 1970s and 1980s has increasingly shown that different sciences carry labels of social irresponsibility or of social responsiveness; and of being "objective" and detached and uncaring, or of being people-oriented and curative.

Thirdly, different sciences and technologies carry labels of difficulty or ease, and of vocational usefulness (and therefore worth pursuing even if difficult), or of free-floating non-vocational interest.

Different researchers have related each of these aspects to sex-differentiated patterns of enrolment, retention and progression, and in practice it is not possible easily to separate them out because of their inter-reaction.

THE MALENESS OF SCIENCE

Many researchers have written of the perceived maleness of science; some of a patriarchal structure and bias in content, others of a male attribution. Arnold Pacey, for example, saw technology ("the application of scientific and other knowledge to practical tasks by ordered systems that involve people and organisations, living things and machines" [Pacey, 1983, p.6]) as not only value-loaded but as focussing on ranges of activities traditionally interesting to men but excluding the work of women, and saw a need to "challenge and counteract the male values built into technology" (p.107). Albury & Schwarz also saw science as reflecting "the prevailing world view of the male researchers of woman's inequality" (Broca's 19th century work on brain weights "proving" that women's brains were lighter, now proves to be highly suspect, but prevailed for 50 years). They see the labelling of physics as a boys' subject as an "effective device for keeping girls confined to the humanities and the arts" (Albury & Schwartz, 1982, pp.87-90). Bowling & Martin (1985) see the masculinity of science as based on its dominant assumptions of competition and hierarchy as well as in the choice of (and exclusion of) topics for study. The scientific disciplines, they argue, are constructed as more process and system-oriented than flexible and shifting like human behaviour. But they do not define science precisely, and the argument is weakened when one contrasts different sciences whose construction differs between disciplines.

Others see the maleness of science as a transmitted media process which does not do justice to the actual social orientation and human variance of many aspects of scientific research. Rosslyn Ives also attributes the perceived maleness of science in Australia to the transmission of ideas about the world and conveyed to students by two media: science textbooks and science educators (who in turn learned from books and other educators). In an examination of secondary science textbooks in general science, biology, chemistry, physics, in 1984, males were represented in general science and chemistry books in a ratio (to females) of 5:1; in physics books by 8.6:1; and even in biology by 3:1. Authors also used predominantly male language (he, men, his, boys ...)

in examples in the texts (Ives, 1984). There are many other such studies from overseas research.

We are concerned less here, however, with the intrinsic masculinity (or otherwise) of different sciences, than with the ascription of maleness in different degrees to different disciplines. For example, Weinreich-Haste's studies with English school children found that both sexes rated physics, maths and chemistry as more masculine (4 and 5 on a 6-point scale) although boys rated all three as proportionately more male than did girls. Subjects rated as scientific were also perceived as "masculine, hard, complex, based on thinking rather than feeling". Girls saw science as difficult, "and they also saw complicated and difficult things as masculine" (Weinreich-Haste, 1981, p.221).

In the British Girls in Science and Technology Project, the male "territoriality" of some disciplines rather than others, placed a stronger male label on physics than other school sciences; curriculum materials were seen to be heavily sex-biased, and boys held strongly sexstereotyped views against girls' active interest in aspects of science the boys saw as masculine (Whyte, 1986; Kelly, Smail & Whyte, 1983).

Ebbutt moves the issue nearer the classroom. His follow-up research examined the perceptions of both boys and girls as to whether there was "boys' science" and "girls' science" and if so, what they were. Both sexes, for example, saw elements like metals, batteries, circuits as for boys, and girls saw chemicals, crystals, tie dye as for girls (Ebbutt, 1981). While the origins of this male:female imaging may well lie in the prevailing social stereotypes, researchers argue that science teachers reinforce the image rather than counteract it.

THE SOCIAL IMAGE OF SCIENCE

There is a growing literature on the extent to which the way in which children and school students may see science as a social process and its role in society, may influence their decisions to pursue or to reject and drop (a) science in general and (b) certain disciplines of science in particular. By the mid 70s, a wide range of research had discussed the influence of students' attitudes to science (Ormerod and Duckworth, 1975) and in particular, sex differences in attitudes. And within the latter, the social implications of science have come to emerge as more influential than was considered a decade ago.

Ormerod tested the Brunel Attitude Scale to science in 1969-70 on 261 boys and 264 girls drawn from a wider sample taken from 17 British schools matched for type of school and for single-sex/coeducational. The attitude scale distinguished subject preference, and social attitudes to science and the perceived social responsibility of science. He concluded that his data showed a strong significance between high social scores (ie seeing science as socially responsible) and later choice of science in the case of girls, but, in his sample, a low correlation in the case of boys. This "social factor" had emerged strongly by the third year of secondary education, which Ormerod rightly considered had implications for curriculum design (Ormerod, 1971). The research, though useful in accrediting the issue as an issue, had some weaknesses. Ormerod only used the term "science" in this early research, not distinguishing between physics, chemistry and biology. The Brunel Science Attitude Scale uses "science" simultaneously to describe a school subject ("science is the most boring subject on the timetable", not distinguishing physics from biology) and simultaneously a whole area of life ("with the aid of science, I look forward to a brighter future", "science is destroying the beauties of nature").

Later research subdivided the scientific disciplines more thoroughly. By the mid and late 1970s, Ormerod had worked with a number of researchers to test out different angles of the attitudinal question. Ormerod developed the Brunel Subject Preference Grid (Ormerod, 1975) which he tested in both mixed and single sex schools on 1,200 pupils of 14+ in the top 25% of the ability range. He found not only that the social implications factor was much less evident with biology than with physics and chemistry, but that those with favourable attitudes to the social implications of science (ie regarding science as socially useful, relevant, helpful, exciting etc) were significantly more likely to choose physics and chemistry at 14+ than those with unfavourable or indifferent attitudes (Ormerod, Bottomley et al., 1979). Work by Bottomley and Ormerod using the Brunel SOCATT grid also found that the social implications factor would also override even dislike of teachers for girls, but the reverse was true for boys. That is, girls with a favourable attitude to the social aspects of science would still choose science even if they scored highly on dislike of the teacher. (The research did not, unfortunately, distinguish the sex of the teacher, and it is difficult to relate this therefore to the same-sex role model issue.) (Ormerod, 1979).

Further study of the social image of science, leads back to sex-differentiated perceptions of different elements of science. (For example, boys are more often reported as seeing lasers as useful in war and defence, or negatively; girls more often in relation to the curative and therapeutic use of lasers, or positively.)

A Danish study takes this issue of elements of science further in the context of a major longitudinal study of physics teaching in Danish upper secondary schools. Among other issues, the researchers investigated students' attitudes towards syllabus topics in physics. One central question was "what would you like to learn more about in physics?" While the sex differences are not as great as previous research would lead one to expect, boys are overall more interested in everyday technology and in rockets and space technology than girls; girls more interested in natural phenomena (wind and solar energy, lightning and thunder) than boys (Nielsen & Thomsen, 1985). This and other research into the elements of different sciences, suggest a correlation between perceived traditionally male/female activities and levels of interest - which poses a dilemma for the construction of new curricula. For interest is, in turn, seen by other researchers as highly correlated with a discipline's perceived social responsibility (see the Male and Female Attitudes paper in this series).

Interest is also reinforced (or otherwise) by the media and by textbooks. Pratt et al (1981) in a review of American elementary school science books, found that four of those most frequently used, in 1977, did not cover social problems at all. National Science Foundations materials had only slight social coverage. Albury & Schwartz saw the coverage of science and technology in the national media in Britain as remarkably consistent - "the work of scientists and technologists is a vaguely sinister, mysterious activity that ordinary people cannot understand" (p.107).

American research does not wholly support the British data, however, on attitudes of school students. An American study of the decline in science achievement in 9, 13 and 17 year olds since 1979 led to the National Assessment of Science in 1981-82. The study looked at the image of science defined as "impressions or perceptions which are held by members of a group and are symbolic of basic attitudes and orientations", or in Jungian terms, "deposits of accumulated experience". The main focus was to identify the current images of science in the USA and to check for variations by sex, race and geographic location (Hueftle, Rakow & Welch, 1983). Fewer than half of the 1982 9 year olds recognised that people write stories better than computers. More school students responded positively in 1982 than in 1979 on "persistent societal problems" (pollution, world hunger etc) but there was no overall statistically significant sex difference between males and females. And while boys consistently reported more positive attitudes towards science in general, than girls, the differences were again only of the order of 3%. Boys showed a "statistically significant decline of 30% on socio-scientific responsibility items" (p.25); but girls were 13% less certain than boys that they could have an impact on the problem of running out of resources.

DISCUSSION

Although different researchers have focussed on a variety of aspects of the image either of science or of specific disciplines, with predictably varied results, three common themes emerge from these and other research studies. Image is generally highly influential. Image varies between disciplines and is influenced by male attribution and social aspect. And image appears specifically to influence enrolments in different disciplines.

In the 1985 and 1986 round of WISTA group interviews, engineers most of all tended to see their disciplines as having a major problem of public and educational image - underestimating the social responsibility and human orientation of different forms of engineering and overestimating its "oily-machine oriented anachronistic image". Despite the evidence from research into schooling, few physicists saw problems of image in their discipline. Geologists reported variously on conflicting images - attractive to women if presented as a tidy science, negative to women if presented as a rough outback discipline.

The WISTA data on ten tertiary institutions raises interesting questions on the different degrees of "male-attribution" of the sciences. Overall, the body of recorded research suggests that physics acquires a male label both earlier in the school years and to a greater extent, than does chemistry. In the WISTA institutions, the first year undergraduate enrolments average about 23% female enrolments (physics) but just over 40% female enrolments (chemistry). But by final year and postgraduate work, chemistry and physics are equally male. A cross-analysis of the 1985 WISTA statistics across disciplines, levels and institutions, examined the degree of consistency (or otherwise) of female recruitment to each discipline across institutions. For those disciplines marketed and perceived as more male (engineering, surveying, mining, physics) the image of the discipline appears to override the possible institutional influence: figures are almost uniform, and uniformly low. For those disciplines which are recorded as having a less sex-labelled image (maths, which is sometimes seen as an arts subject; computing), the female enrolments are both higher and more variable. Image seems less uniformly influential. In the Queensland WISTA project, therefore, individual discipline profiles have now been constructed, relating the reported image of a discipline, its secondary (Grade 12) and tertiary patterns of enrolments, its construction, location (in Faculties and in association with others) and marketing, and so on. At this stage, very different patterns of relationships are emerging for physics, chemistry (and biochemistry), biology (and microbiology), and so on, on which the 1988 Research Report will write further.

QUESTIONS

(1) Do you consider that your discipline has a major image problem which affects recruitment? If yes, is this connected with its male/female attribution, and/or its social responsibility image, and/or its anachronistic image?

(2) How is discipline-image most strongly transmitted? By the media? Schoolbooks? Careers advice? Higher education handbooks and marketing?

(3) If you had to rank your discipline on a threepoint scale

Male - Sexneutral - Female

1 2 3

where would you rank it?

(4) How most effectively could your discipline-image be improved? By higher education staff? Professional institutes? School staffs? The media?

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